

## COMFORT REPORTS

# TECHNICAL REPORT

*Advanced Comfort Criteria*

*Human Comfort Field Studies*

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Arnold Schwarzenegger, Governor

***Prepared By:***

Davis Energy Group  
Dave Springer  
123 C Street  
Davis, California 95616  
Contract No. 500-98-024

***Prepared For:***

**California Energy Commission**

Phil Spartz

***Project Manager***

Nancy Jenkins

***PIER Buildings Program Manager***

Terry Surles

***PIER Program Director***

Robert L. Therkelsen

***Executive Director***



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## Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems Integration

What follows is an attachment to the final report for the Alternatives to Compressor Cooling Phase V project, Contract Number 500-98-024, conducted by Davis Energy Group. This project contributes to the PIER Building End-Use Energy Efficiency program.

This attachment, “Comfort Reports” (Attachment A-4), provides supplemental information to the project’s final report and includes the following documents:

- *Advanced Comfort Criteria*
- *Human Comfort Field Studies*

For more information on the PIER Program, please visit the Commission's Web site at: <http://www.energy.ca.gov/research/index.html> or contact the Commission's Publications Unit at 916-654-5200.

## **Abstract**

This “Comfort Reports” attachment is a set of two documents produced by the Alternatives to Compressor Cooling Phase V project, funded by the California Energy Commission’s Public Interest Energy Research (PIER) Program.

The multi-year Alternatives to Compressor Cooling Phase V (ACC) Project has the goal of reducing residential peak load in California by using nighttime ventilation to cool houses that are designed for optimal summer performance and that potentially eliminate the need for air conditioning in transition climates.

This attachment, “Comfort Reports” (Attachment A-4), provides supplemental information to the project’s final report and includes the following reports:

### *Advanced Comfort Criteria*

The purpose of this report is to explore the attributes of an ACC house design within the context of a definition of comfort that applies to the residential environment.

### *Human Comfort Field Studies*

Though much research has been completed to develop an understanding of comfort in commercial building settings, little is known about the variety of comfort perceptions of people in residential environments. This report documents the results of qualitative field research on how people define comfort in residential settings, thermostat use, and the use of windows and mechanical devices to improve comfort.

**ADVANCED COMFORT CRITERIA  
&  
ANNOTATED BIBLIOGRAPHY ON ADAPTED COMFORT**

**Deliverable for Sub-task 2.3.4**

**Alternatives to Compressor Cooling - Phase V**

California Energy Commission Contract No. 500-98-024

**June 30, 2003**

M. SUSAN UBBELOHDE

GEORGE A. LOISOS

ROBERT MCBRIDE

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## SECTION ONE: ADVANCED COMFORT CRITERIA FOR ACC HOUSE

### I. HOW IS COMFORT DEFINED?

#### A. CURRENT RESIDENTIAL PRACTICE

A comfortable thermal environment is an expectation for a typical occupant of a new house. Even though the average occupant does not appreciate it, this is a complex achievement. At a gross level, houses exclude outside weather from the inside of the house. Once that is accomplished, the building acts as a thermal moderator by damping out the diurnal thermal variability and by moderating temperature extremes. The capacity of the building to do this is governed by a number of parameters, including the insulative capacity, the orientation and size of windows, the air tightness and the thermal mass of the structure itself. A house in which these design parameters have been optimized for summer performance in a particular climate is referred to in this report as an "ACC house" (see Section III). Once the building envelope and mass exceeds their capacity to provide comfortable conditions inside, backup systems such as furnaces and air conditioning are called upon to assist the house in maintaining comfort.

In current practice what have contractors, homebuilders and designers done to provide superior comfort for their clients? In short, other than code mandated requirements on building envelope, the houses rely on a brute force attempt in making comfort. If you don't like your current thermal environment you have the ability to change it by using machines that heat and cool. Easily understood by the public this strategy has the perception of success and provides fewer complaints than traditional houses not equipped with massive thermal conditioning equipment.

This ability, however, to easily manipulate the thermal environment has allowed builders to create houses that disregard their environmental conditions. Builders assume that since the houses are equipped with adequate machinery they can handle any thermal task given to them. As Cooper (1998) notes: after 1950, the "passive" climate-control features of homes were often sacrificed to pay for the air conditioner.

Historically, design of the thermal performance features of a house was done by trial and error. Even today with all of our predictive abilities houses are routinely designed with little regard to actual thermal performance, save that required by building codes, such as, Title 24. As Brown et al (1996) notes, "Oversizing of residential air conditioning is the industry and consumer norm." Builders work with experience, they use it for sizing



equipment and construction principles. What worked on one house will be emulated for others.

Changing practices or experimentation is expensive and the results unpredictable for the builder and they try to avoid it. At the same time they need to differentiate themselves from their competition and in this way they try to introduce incremental features to show a steady progress to a “better” house, a new approach, an up to date home. It is these changes that introduce comfort wildcards such as large expanses of unprotected glass that may affect the comfort performance of the house, usually without the knowledge or understanding of the builder. The new homeowner, conditioned by modern expectations of performance guarantees, assumes that the house is comfortable. The builder similarly assumes that modern conditioning machines (furnaces and air-conditioners) are sized to ensure that the structure will maintain its comfort. When it does not the assumption by both builder and homeowner is that something is wrong with the machine, not the house.

The objective of the Alternatives to Compressor Cooling project has been to design and deliver a house in which the occupants are comfortable enough to not desire compressive cooling technology, or in hot climates to significantly reduce dependence on compressive cooling. A clear and accepted definition of “comfort” for residential occupants is critical to defining such performance criteria. Since the most widely-accepted of the standards have a close relationship to compressor cooling, the research rethinks the appropriateness and applicability of these standards as criteria for the compressorless house.

Brown (1996) identifies a major problem with assuming the air conditioner is totally responsible for summer comfort: the use of a single criterion pushes everyone involved (home owner, contractor, HVAC supplier) to install a larger capacity system than necessary and to operate it for zero percent exceedence of a narrow comfort zone. As Brown notes: "The crucial step in moving away from the single criterion approach appears to involve the creating and fostering of an effective characterization of the additional attributes" of a non-compressor approach. The purpose of this report is to explore the attributes of an ACC house design within the context of a definition of comfort that applies to the residential environment.

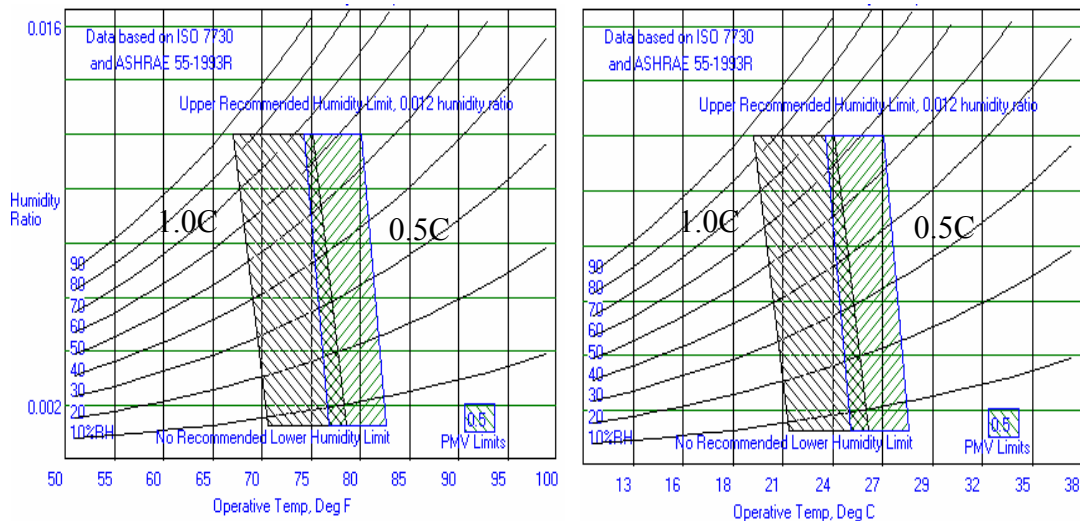
## **C. ASHRAE STANDARD 55**

### **1. Background**

Detailed comfort analyses have resulted in standards and practices to assist in the design of the buildings. The most accepted standard for thermal comfort in the United States and internationally is published by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). This document, ASHRAE Standard 55, has been developed and revised based on laboratory data and field studies over the last five

decades. ASHRAE Standard 55 defines the conditions in which a specified percentage of the occupants of a space will find their immediate environment thermally acceptable. Standard 55 is intended for the design, commissioning, operation and testing of buildings and other occupied spaces and their HVAC systems, and for the evaluation of thermal environments. The stated purpose is: "To specify the combinations of indoor thermal environmental factors and personal factors that will produce thermal environmental conditions acceptable to a majority of the occupants within the space." (ASHRAE Standard 55-1992R)

To do this the Standard identifies six factors in thermal comfort. The environmental factors are temperature, thermal radiation, humidity and air speed. The personal factors are activity level and clothing. The theory is that if a building and HVAC system manages the environmental comfort variables and the occupants are doing their best to balance their metabolic rates with their clothing values, the majority of occupants will register satisfaction with their thermal environment.



**Acceptable Range of Operable Temperature and Humidity (ASHRAE 55 Fig 5.2.1.1-1)**

The main metric of comfort in Standard 55 is the Predicted Mean Vote (PMV), an index that predicts the mean value of the votes of a large group of persons on a 7-point thermal sensation scale. In addition, the Predicted Percentage of Dissatisfied (PPD) is an index that establishes a quantitative prediction of the percentage of thermally dissatisfied people determined from PMV.

In defining the conditions for comfort, Standard 55 offers three classes of comfort as goals or criteria for performance. These classes (A,B and C) differ in the allowable PMV range and therefore, the PPD. In other words, a C class space will, by definition, have a larger percentage of dissatisfied people and therefore, it is assumed, a wider boundary of allowable thermal conditions than an A class space. The classes do not differ by building program, activities, climatic location or number of occupants.

## 2. Comfort Preference Data: chamber studies versus field studies

One of the greatest concerns in applying ASHRAE Standard 55 to a house designed using ACC principles lies in the substantial use of comfort chamber research in developing the standard. Most of the researchers developing the adaptive comfort model identify this issue as fundamental to the need for the adaptive comfort model.

In his article summarizing the discussion of comfort standards and building energy use, Lovins (1992) reviews much of the literature related to comfort standards. The research indicates that the conventional comfort model developed from comfort chamber research is seriously flawed. By basing the ASHRAE design standards on this model, resulting systems may not assure optimal comfort and energy will be unnecessarily wasted in the process. Lovins launches his criticism by pointing to a surprisingly wide range of comfort temperatures reported in tables included in Fanger's own seminal work (although not remarked upon in that text). Lovins proceeds to introduce a variety of findings from field comfort studies and behavioral research that reinforce the idea of variability across populations, as well as within the experiences of individual actors through time, across different social contexts, as a result of interaction with technologies, and as a function of the ways in which comfort questions are posed by researchers.

Others (Humphreys 1996 ; Humphrey and Nicol, 1998; Brager and DeDear, 1998) argue that there is an important difficulty in reconciling the results of comfort studies which use varying research methods: "the comfort temperatures found from the various field studies vary notably one from another" and are different yet from laboratory results and predicted or calculated results from "rational indices". Whereas research on comfort undertaken in "comfort chambers" shows fairly consistent and similar temperature preferences even across cultures with highly variable climates, studies of comfort "in the field" reveal much more variation, especially in the case of occupants of "naturally ventilated" or "free running" buildings without centralized heating and cooling systems. In the latter case, acceptable temperatures appear to closely lag changes in the outdoor temperature in ways tracked by, but not explained by, behaviors such as clothing changes or the use of fans; persons' "expectations" seem central: "people grow to accept the thermal conditions they've become accustomed to." The conflicting findings of comfort chamber and field studies suggest that there are different forms of thermal comfort or that comfort is "context-dependent" or "situational."

Hackett and Lutzenhiser (1994) offer an expanded perspective on the problem of defining comfort in their review of comfort literature from a sociological perspective. "In the world outside comfort chambers, actors seem to exhibit considerable individual and situational variability in perceptions of comfort. The discovery of the "real" person in modeling and forecasting means that designers can shift their emphasis from the creation of "ideal" to "acceptable" conditions... design attention should focus on the *different experiences* offered by alternatives such as evaporative cooling, shading, radiant cooling, etc."

### 3. The Adaptive Comfort Model

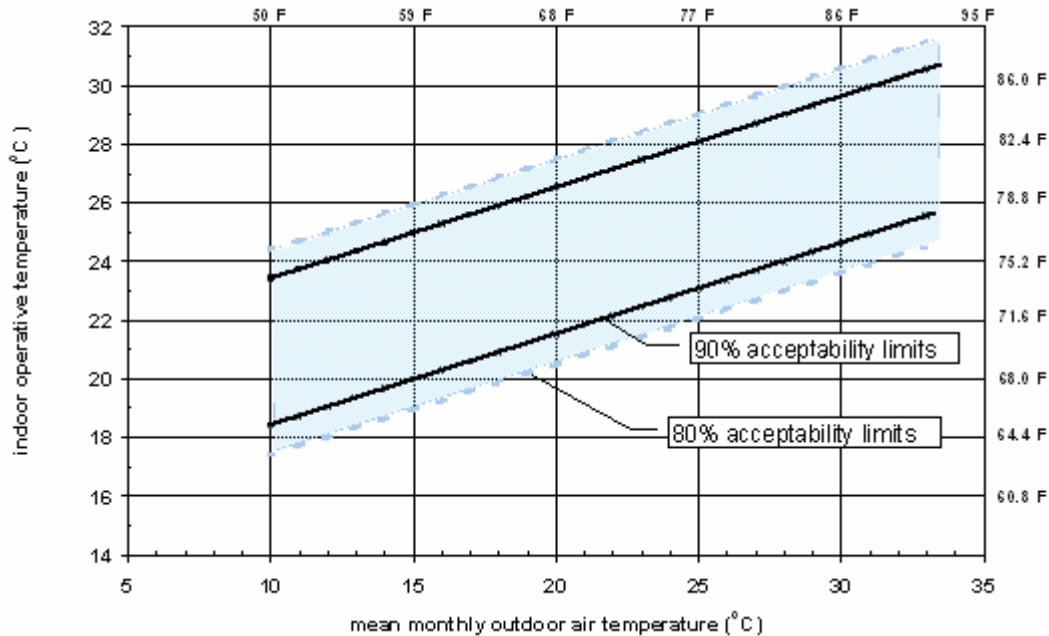
Throughout the period of this project, ASHRAE Standard 55 has been undergoing review and revisions related to issues of naturally ventilated buildings, in which perceived comfort is affected by the exterior weather conditions and a range of adaptive actions on the part of the occupants. In 2001, Standard 55-1992R, Thermal Environmental Conditions for Human Occupancy, was approved for public review. Changes to the standard include new data on adaptive response in passively ventilated buildings.

Adaptive responses to changes in indoor climate are divided into three categories. (DeDear and Brager 1998) *Behavioral* adaptations include changes of clothing, adjusting the HVAC system, or arranging activities during the day to accommodate climate. *Physiological* adaptations include any unconscious bodily response to repeated exposure to thermal environmental factors that tend to decrease the strain or discomfort resulting from that exposure over time. *Psychological* adaptation is described as the expectations arising from past experience being altered by repeated exposure to thermal environmental factors, such that comfort in a new indoor climate grows with familiarity.

Section 5.3 of the standard details the alternative criteria for naturally unconditioned spaces "where the thermal conditions of the space are regulated primarily by the occupants through opening and closing of the windows. Field experiments have shown that occupants' thermal responses in such spaces depends in part on the outdoor climate, and differs from thermal responses in buildings with centralized HVAC systems primarily because of the different thermal experiences, availability of control, and shifts in occupant expectations." A key field study by Busch (1992) using careful comparative design (e.g., comfort reports from both mechanical air conditioned and naturally ventilated workplaces) found significantly higher reported comfort temperatures in the non-AC settings.

In short, the adaptive comfort model recognizes that in buildings that are naturally ventilated, the occupants will tolerate a wider range of thermal conditions, that these will vary seasonally and are closely related to outdoor conditions. According to the Standard, such buildings must not be equipped with mechanical cooling (such as compressive cooling) and the primary means of ventilation must be personally controlled operable windows. Mechanical ventilation may be utilized, but not as the primary means of regulating conditions.

Acceptable operative temperature ranges are specified in ASHRAE 55 Figure 5.3.1 shown below for naturally conditioned space:



The operative temperature is assumed to be the mean of the air temperature and the mean radiant temperature when the difference between the two are small. In this way, the ACS begins to recognize the potentially positive role of the surrounding surface temperatures in achieving occupant comfort. A more precise calculation of operative temperature includes the effect of both the air speed and the mean radiant temperatures on air temperature, beginning to incorporate two important factors which can mitigate effects of uncomfortable air temperatures. (Appendix C in Standard 55-1992R - Draft).

The Adaptive Comfort Standard (ACS) is an important move in the right direction for evaluating comfort in an ACC house. Because the house is designed to use air movement for comfort cooling and thermal mass to provide mean radiant temperatures lower than the air temperature, as well as operable windows and mechanical ventilation with outdoor air, the calculated comfort temperature boundaries have moved closer to the reported comfort temperatures in the various field studies. However, some aspects of the ACS do not well address the potential comfort perceptions and achievements of the ACC house. These are discussed in the following sections.

#### 4. Programmatic Challenge: a house rather than an office

Many assumptions imbedded into Standard 55 best address the building program of the office or similar large collection of building occupants in a work setting. To the extent that a house is different than this scenario, the standard can become problematic in application. Studies of actual temperature preferences and air conditioner usage within households reveal differences in preferences and a tremendous amount of variation in thermostat settings and AC operation patterns. Based on these findings, Lovins (1992) argues that while the application of the chamber-based models to offices may be problematic, their application to households is completely inappropriate.

The comfort performance of a house is likely to differ from the Standard (including the Adaptive Comfort Standard) in the following aspects:

- ▮ **Activities.** The Standard is developed from data for sedentary or near sedentary physical activity levels typical of office work. It does not apply to sleeping or bed rest, or to children, the disabled or the infirm. Although various metabolic rates can be recognized and used, activities in a house tend to be quite varied over short periods of time, somewhat unpredictable in time and place, and varied from individual to individual. Finding some agreement on input conditions to generate a comfort zone for more than one room or for all family members for even an hour would be a challenge.
- ▮ **Size of population.** The given population is small and the politics of habitation may be a more important determinant. For example, a dominant member of the household may influence not only the thermal conditions of how the house performs, but also the opinion of the rest of the "group", which may be only a spouse. Although the thermal preferences and tolerances of an individual may be physiologically based, when there are only a small number of occupants within a building, such as a house, a difference in preferences becomes part of the social situation of the household as much as physiological. As documented in Task 2.3.5 Human Comfort Field Studies (Hackett and McBride 2001), "There is as well a virtually routine and almost predictable division of thermal preferences - sometimes acrimonious - even within households; in almost every case spouses' preference were not the same." This division is not likely to be one that can be solved with a house design or control, but played out only by the occupants in the house.
- ▮ **Steady state assumptions.** The Standard addresses thermal comfort in steady state conditions only. Even beyond natural ventilation, which connects the interior to varying exterior conditions, a house tends to cycle through great flux in internal gains, external gains (single family houses have full exposure to all orientations and the roof) and the connection between the two (doors opening, windows opening).
- ▮ **Natural ventilation or HVAC but not combined.** The Adaptive Comfort Standard specifies that it is applicable only for buildings without any mechanical conditioning, except those with heaters that are unused during periods the standard is applied. However, the ACC house that is designed for hot climates would typically have a back-up mechanical system specifically to deal with heat storm periods and it is the operation and control of that system **in concert with the natural ventilation** that allows the building to perform.
- ▮ **"Circumstantial restraints" minimized.** In domestic situations, the role of choice and flexibility in possible adaptive responses is, in many ways, maximized well beyond the office, industrial or institutional working situations. People in their own homes have a wide latitude in choice of clothing, activity and location

in order to make the adjustments necessary to be comfortable. In this way, they face perhaps the fewest "circumstantial restrictions" described by Humphreys and Nicol (1998).

## **II. COMFORT DEFINITIONS BEYOND STANDARD 55**

In this section we review factors which have been identified in the literature and in Human Comfort Field Studies completed under this project that add nuances to the definition of comfort beyond even the adaptive comfort model in Standard 55.

As we attempt to understand the range of factors which affect thermal comfort, there are aspects to both a house and the occupants which will impact the interpretation of those six comfort factors used in Standard 55 and therefore the appropriateness of the Standard for evaluating comfort performance of an ACC house. Some specific aspects of thermal comfort identified in Standard 55 as problematic (air movement, radiant surface temperatures different than air temperature, temperature variations in time) are those which can directly contribute in a positive manner to the thermal performance and operation of the ACC house. In order to develop a criteria for thermal performance, the role of these factors, as well as others, must be included.

Defining a useful criteria goes beyond simply identifying and quantifying all relevant factors. In the design and expected operation of the ACC house, we are shifting the paradigm of the person in relationship to their environment back to a more active acknowledgement and engagement with that environment. As Bruce Hackett expressed in an ACC project memo of September 8, 2000: "...we're working here in the context of a broad shift from one 'model' of man to another, from, in the main, passive to active. This means, among other things, that comfort is no longer simply a sensation, but more like an achievement. It means that the experience of comfort is mediated by who one 'is' and what one is doing, and this means a movement away from homogeneity toward diversity - people aren't all the same, the experience of comfort changes over time via 'adaptation', and comfort is 'situational' (meaning, e.g., that comfort chambers tell us about comfort in comfort chambers)."

In a similar vein, Brager (2002) has noted that "methods for defining a 'comfort zone' or 'comfort range' of acceptable temperatures are based on associating ideal conditions only with a feeling of neutrality, or being totally unnoticeable." But in times when exterior conditions are thermally stressful, neutrality and "not noticing" may not serve well as the criteria for interior thermal comfort.

### **A. ADAPTATION PHYSIOLOGICAL FACTORS**

This section identifies a range of *potential adaptations* which the occupants of the house can pursue if the house has moved beyond the boundaries of the Adaptive Comfort Standard. These are the same comfort factors recognized in Standard 55 which have

been shown in studies to broaden comfort temperatures beyond the boundaries of the ACS: air movement, mean radiant temperature, and dry bulb temperature.

## **1. Air Movement**

The accepted standard, ASHRAE 55, has historically been set to guarantee levels of certainty which are hard to achieve without full mechanical control of the interior environment. A recent revision of the standard, ASHRAE 55-92 with a 1993 addendum, specifies the following summer comfort criteria to create an interior thermal environment acceptable to at least 80% of the occupants if they are primarily sedentary (<1.2 met) and wearing typical summer clothes (0.5 clo): 73-79 degree F at 60% RH. Comfort is assumed at these levels with no minimum air speed required.

ASHRAE 55-92 also recognizes that increased temperatures can be offset with air movement. A limit is placed on air velocity, and therefore temperature increases of not more than 5.4 degree F above the comfort zone can be achieved with 160 fpm. For non-sedentary people, the chart allows a maximum of 300 fpm to enable a temperature rise between 4 and 8 degrees F, depending on the relationship between air temperature (dry bulb) and the mean radiant temperature.

The emerging Adaptive Comfort Standard considers air movement cooling with air speeds under 157 fpm and up to 85.1 degrees, or 5.4 degrees F. above the prescribed temperature range of 80 degrees at 40%RH as an alternative to active cooling capacity to below 79.7 degrees.

Research by Scheatzle, Fountain, Rohles and Wu (summarized in Arens et al. 1995) has addressed the limits of air movement as a strategy for increasing comfort at higher temperatures. Rohles recommends an 'extended' comfort zone using 160 fpm as the limit for air movement, which was incorporated into the ASHRAE Standard 55 in the 1981 version. Following this, Rohles and Spain determined that up to 200 fpm air movement was acceptable and considered pleasant, but higher temperatures were not tested. Scheatzle extended the conditions tested to include lower and higher relative humidities and determined that the upper limit of acceptability for air motion could be raised for lower humidities (up to 88 degrees F). Wu found the acceptable zone to go as high as 89.6 degrees F for oscillating room fans. Japanese researchers report similar results in air-movement-cooling studies. Arens et al (1998) found that a fluctuating fan operated at up to 276 fpm made inactive people comfortable as high as 86 degrees F.

Additional research performed using the controlled-environment chamber at UC Berkeley was designed to test conditions as close as possible to those assumed by ASHRAE Standard 55: metabolic rate of 1.2 met, 0.5 clo, RH 50% in a controlled laboratory setting simulating residential conditions. These tests confirmed that it is possible to maintain comfortable conditions in a residential setting up to 88 degrees F if the air velocity of 200 fpm is available over the upper body with the air movement personally controlled.



The Human Comfort Field Studies discovered that, among the populations interviewed in Davis and Gold River, California, ceiling fans were received with nearly unanimous enthusiasm. Some respondents even identified the *sound* of the ceiling fan as an amenity. As Hackett summarizes the interviews in an ACC project memo on September 8, 2000, "...the ceiling fan itself seems to be a current 'social movement', if you will and you can't have too many of them."

## **2. Mean Radiant Temperature (MRT)**

Thermal mass within the insulated space can affect the comfort conditions in two major ways: through impacting perceived comfort without changing the measured air temperature and through storing heat to lower the measured air temperature over a non-massive construction.

As recognized in ASHRAE 55, the temperatures of surfaces in a room can affect perceived comfort, especially when they deviate from the dry bulb air temperature significantly. Standard 55 is principally concerned with discomfort that can arise from surfaces with radiant temperatures different than air temperature; cold floors during winter periods, hot ceilings during summer and radiant asymmetry which reduces the "thermal acceptability" of the space. Floor temperatures which deviate too much from the air temperatures are considered to contribute to discomfort. (Class A, the floor is allowed to range from 66.2 - 84.2 degrees F while class C the allowable range is 62.6 - 87.8 degrees F.)

However, in the Adaptive Comfort Standard, the operative temperatures used to define limits on comfort conditions *do* include the impact of MRT as well as air movement on measure air temperatures. There is, however, no discussion of the potential for increased comfort due to surface temperatures that differ from the air temperature. While the perceptual cooling effect may be desirable from a comfort standpoint, and recognized in the calculation of operative temperature, this is not identified in the text or recognized as an explicit cooling strategy.

The role of mass in reducing the measurable temperature (rather than the perceived temperature) during overheated periods was addressed by Givoni's project team in Phase I of the ACC project. Field monitoring of test cells in Phase I of the ACC project by Givoni and Labib (reported in Ubbelohde 1996) indicated that increased thermal mass can provide either decreased or increased comfort for occupants depending on the use of shading and ventilation, as well as the control strategies. For high mass interiors, shading from solar radiation and the use of night ventilation kept the interior air temperature well below the exterior air temperatures, working most effectively during peak overheated periods.

### 3. Exterior Conditions as Context

Humphries (1996) among others suggests that comfort is “context-dependent” or “situational”, a way of understanding results related to both experience and expectation, both physiological and psychological. The definition of “context” and “situational” can be broadly understood. For example,

**a. Acclimatization by season and location.** Humphreys (1996) found that people tend to remain comfortable through temperature changes that are seasonal, but that discomfort arises when changes occur within much shorter periods, e.g. a day or week. Similarly, many studies (Busch 1992 and Kwok 1998 among many) identify comfort temperatures dramatically higher among occupants in tropical countries and in locations with much higher outdoor temperatures.

**b. Diurnal swings.** Predictable diurnal changes are different than the short period changes that provide discomfort. These tend to be appreciated and understood to be critical for thermal comfort. The availability of nighttime relief plays a role in adjusting to a hotter daytime temperature. The common summer baseline low temperature throughout California is driven by the large thermal mass of the ocean, which is a near-constant 55 to 57 degrees. Before the 1960s statewide, and even today in many coastal communities, night ventilation by opening windows has been the primary means of summer cooling. If there is any cultural norm among those native to California’s population centers, it is a positive opinion of the nighttime ocean breeze coming in after a hot day. In fact, we feel that cool mornings during a hot summer can be a blessing, allowing household chores requiring high metabolic activity to be completed in unusual comfort, early in the day.

For the morning coolness to be acceptable requires the previous day’s temperature to be over, say, 85-90 degrees F., with an expectation of the same for the day to come. During a run of cooler days, morning cooling is not acceptable; for example this sort of pattern occurred during a late August 2000 series of storms in the California Central Valley. In the months of summer heat (95 to 105 degrees F.) experienced in the Central Valley, morning temperatures as low as 60 degrees is most likely to be perceived as unconscious delight, and in our interviews (ACC Phase III and IV) has never been referred to as a discomfort. Users of a night ventilation cooling system who were interviewed tended to view the morning coolness below the ASHRAE Standard 55 prescribed summer minimum of 73.4 degrees F. as a luxury attained for free, an inexpensive excess of pleasant experience beyond thermal neutrality.

**c. Alternative Cooler Locations.** The presence of alternate cooler locations may effectively raise the comfort temperatures identified and used by a house occupant. Field studies completed for this project (Human Comfort Field Studies, Hackett and McBride 2001) revealed that easy access to a swimming pool, as an alternative means for cooling down, affected thermostat settings. “Those with pools tend to opt for higher thermostat settings. Some use the pool as personal evaporative cooling, and/or may have been hit by

large energy bills and adjusted. Kids of families with pools may not touch the AC but are told to jump in the pool when hot."

In these field studies many of the house occupants "seemed fatalistic rather than seriously annoyed about the fact that their homes' second stories were much warmer than their 'comfort zone' would allow in the afternoon and evening." They simply did not use those spaces until they were cooled down. Similarly, when Lutzenhiser (1992) interviewed families renting University owned on-campus apartments at UC Davis he found that a common strategy for many was avoiding the indoors by using the library or patio and barbeque from about 4 to 9 p. m. during hot summer days.

## **B. CIRCUMSTANTIAL RESTRAINTS: BEHAVIORAL, SOCIAL AND CULTURAL FACTORS**

BRAGER (2001) notes that "comfort is almost impossible to measure directly. As a result, scientists have resorted to measuring only the physical variables that influence a body's heat exchange with the environment, asking questions about thermal sensation (and sometimes preference), and then making *assumptions* about which of those sensations might be associated with satisfaction or dissatisfaction. (A simple but not so far-fetched analogy would be asking someone what color the room is, but then making an assumption about whether they like it or not)." In this section, we identify those aspects of thermal preference which relate to an individual's behavior and social and cultural context, and describe the range of "*circumstantial restrictions*" or "*individual and situational variability*" that may support or bound the occupants' use of adaptive actions used to achieve comfort.

### **1. Wide-Ranging and Elastic Individual Preferences**

One of the reasons that Standard 55 defines comfort performance as with the metrics of PMV and PPD is that individuals can vary widely from each other in their comfort preferences and tolerances, as well as vary across time and circumstance. Rather than attempting to define comfort as 100% of occupants reporting themselves comfortable, a percentage of occupants is determined to be sufficient. When the goal is to provide comfort to large numbers of occupants in one building, this metric makes sense. However, when there may be one, two or five occupants, individual definitions of comfort and their tolerances become important.

Field studies of house occupants in Davis, California and Gold River, California offer support for the difficulty of relying on individuals to define comfort. As documented in the Human Comfort Field Studies (Hackett and McBride 2001), a large number of house occupants demonstrated a "considerable spread" and a "large amount of variation" in their preferred and tolerated temperatures. Ideal low temperatures ranged from 60 degrees F to 80 degrees F, while ideal high temperatures for the house ranged from 72 degrees F to 90 degrees F, while the relative tolerable ranges are 50-78 degrees F and 77-98 degrees F.

These variations may well be a result of age, menopause, gender, childhood geography and many other factors which individually impact people's preferences. For example, In Thailand, Busch (1992) found that people working in air conditioned offices used air conditioning in their homes twice as much as people working in naturally ventilated office buildings. The point is that individuals vary a great deal and for many reasons in their comfort preferences and not all variations can be predicted for residential occupants.

## **2. Occupant Control**

A critical component of the adaptive comfort model is the ability of occupants to control their thermal conditions. Hence, in the Adaptive Comfort Standard section in Standard 55 -1992R for naturally ventilated buildings, access to and control over the operable windows is required. This issue of control is heavily recognized in the literature and the impact on expanding the range of tolerated temperatures may very well be much larger than the Adaptive Comfort Standard reflects.

A number of studies in the 1992 special issue of Energy and Buildings examine use of air conditioners. Kempton, Feuermann and McGarity (1992) report that most users of room air conditioners leave the temperature setting at the coldest level and turn them on and off manually, in spite of the fact that they were equipped with thermostatic controls. A Pacific Gas and Electric study cited in the Human Comfort Field Studies (2001) echoes this relationship that examines load profiles for houses with central air conditioning. This study found that a large proportion of households, perhaps as many as two thirds, "continuously adjust and re-set their systems in reaction to real or perceived climate changes and building performance." This adjustment is a method of trying to directly control the system, rather than letting the thermostat operate as programmed. The Human Comfort Field Studies (2001) found a similar result, reporting that very few of those interviewed program their thermostats and leave the system to provide comfort. Many more of those interviewed prefer to operate their systems manually.

Field studies identified by Brager and deDear (1998) confirm the importance of persons' control --real or imagined-- over their thermal environment as enlarging the range of acceptable indoor climates. People working in offices where temperatures are centrally controlled are comparatively very sensitive to minor temperature fluctuations, and the authors speak of the "treadmill" of control: the more centralized the control the more "stringent" the expectations. Control is related to the type of building, with the "free-running" type offering more "adaptive opportunity" than the centrally controlled version.

## **3. Non-comfort Environmental Factors: noise, security, cost**

There are other non-comfort factor variables in the environment that may strongly govern the operation of a house for comfort, the choices occupants make and the resulting definition of comfort or discomfort they develop. In the Human Comfort Field Studies, operable windows were one of those adaptations most affected by these factors.

Residential occupants identified worries about security in opening a window to the outside, about unwanted noise from outside traffic and the neighborhood. On the other hand, respondents also identified unwanted noise from air conditioning and the thermal shock that one may experience between an air conditioned inside and the outside as negative factors in using compressive cooling.

Although it is possible to know and predict the comparative cost of compressive versus non-compressive cooling, studies have found that comfort decisions are not always made on a cost basis. Hackett and Lutzenhiser (1991) found that when tenants paid for their own use (rather than sharing the cost to the entire complex equally with all other tenants) their energy-use tended to drop even if their bill was now less than when the cost was the same to everyone. Reduced air-conditioner use accounted for almost all of the reduction in energy consumption, and there were few expressions of discomfort.

#### **4. Social Factors: cooling for guests / cultural narratives /political statements**

There is also evidence in the literature that people see comfort as a social and situational consideration in which there can be a division between the house as a "private" place for family in which comfort boundaries are expanded, and the house as a "public" place for guests or visitors with a more narrowly drawn comfort zone. The Human Comfort Field Studies (2001) discovered that most of the respondents in Davis, California reduce the temperature when guests are coming as compared to when they are in their house without company. This strategy is reflected in earlier studies from both California and Florida cited in Brown (1996) in which respondents say that thermal conditions that may be tolerated by the family might be considered uncomfortable for guests. This is a significant change from the decades in which air conditioning was first introduced. Cooper (1998) describes that air conditioning was resisted in good part because it implicitly attacked the "social rituals" of hot weather –light clothing, cold drinks, vacations, swimming.

An additional comfort variable is a cultural preconception of the climate and how it is "supposed to feel" as opposed to what it actually is. An extreme example of this is a case study in India (Ubbelohde and Loisos 1990). The Pol House, a courtyard house in a very dense urban fabric, performs admirably during the hot dry season, but poorly during the monsoon season. The house during that time overheats and is far too humid compared to other house types in the city. However, when asked, occupants seem to minimize the monsoon experience for a variety of reasons. Some of these reasons rely on the relative comfort that the onset of the rain brings before the humid conditions fully develop. As the hot dry season reaches its climax the onset of the rains have an immediate cooling effect. That memory in addition to a host of cultural associations of fertility and renewal in effect mask the reality of truly miserable thermal conditions. In India the comfort perception is far better than it is by western standards

In California the opposite occurs. The actual number of overheated hours tends to be quite low. However, memory of them persists and causes people to disproportionately react by purchasing expensive cooling plants when a large number of them do not actually need them. In this way it is quite important to take into account the perceptual idea of comfort in addition to the physical one.

## **5. Expectations: of technology and of thermal conditions**

The importance of how the technology works and what can be expected of it has been identified by Hackett in his ACC project memo of September 8, 2000. "Comfort is not abstract. Air conditioning produces one Type, and there are others...it means that comfort 'criteria' are not a priori but are, instead, intrinsic to the technology, emergent in the process of using that technology. " Kwok's study (1998) of over 1000 students in schools in Hawaii echoes this point. Those interviewed expected a cooler and more closely bounded range of temperatures from the classrooms which were air conditioned than those which were cooled by natural ventilation and they modified their comfort assessments using these expectations.

Humphreys and Nicol (1998) also identify expectations related to conditioning capabilities as a contributor to the determination of a comfort temperature. People develop very different expectations of comfort relative to whether the building is totally controlled by a mechanical system, naturally ventilated, or "free-running" with no mechanical conditioning and therefore very little freedom of choice or control of temperatures at all.

Lovins (1992) considers research on variability within the experience of individuals in terms of their reported comfort preferences and tolerance for heat. There is evidence, for example, that persons learn to expect particular temperatures as appropriate to particular sorts of places (offices, theaters, churches, malls, homes, indoors vs. outdoors, etc.). Those expectations are, of course, learned and not innate, and persons appear to be quite willing to tolerate quite different environmental conditions in different settings—as long as conditions are considered appropriate to those settings.

Humphreys and Nicol (1998) identify expectations related to climate as a contributor to the determination of a comfort temperature. People determine comfort temperatures in close relationship to the temperatures and patterns they experience outside. Brown (1996) further cites studies by Parker and Hackett and Lutzenhiser that tie comfort demands to the hottest day of the year in contrasting ways. In Florida, mechanical systems tend to be oversized so that they can respond to extreme conditions. This makes sense in that the summer is already hotter than comfortable in general, there is little nighttime relief due to cloud cover and humidity, and the length and timing of an extreme hot spell is unpredictable. In much of California, however, overheated periods are more easily identifiable as "heat storms" or "Santa Annas". They seldom last more than three to five days and occur a few times each summer. The studies have found that many will consider these predictable, short term conditions as "acceptable".

### III. CHARACTERISTICS OF THE PROPOSED ACC HOUSE WHICH AFFECT OCCUPANT COMFORT

While it is possible to attain comfortable conditions by combining all the thermal comfort variables in sum total, for example, delivering a low air temperature to try to balance out disproportionate levels of MRT, lack of air movement, humidity, clothing and metabolic rates. However, attaining comfort is far easier if ALL variables individually stay within prescribed limits. This is why insulated houses are more comfortable than non-insulated houses, why double-glazing is more comfortable during winter nights than monolithic glass irrespective of furnace size. Keeping all variables within limits can explain how some buildings maintain near universal comfort (very low complaints) under extreme conditions better than others.

This section details the design specifications for the compressorless house (transitional climate and the inland house with small compressor) which directly address and impact the thermal comfort of the occupants during heat storm overheated periods. These aspects of both construction and operation are related to defining and delivering comfort.

#### A. HOUSE CONSTRUCTION

**1. Reducing Heat Transfer.** These design features form the first line of defense - stopping and rejecting the heat before it enters the occupied areas of the house and becomes part of the measurable air temperature.

**Roof Insulation.** In the roof, the increasing use of truss systems permits the easy addition of increased insulation levels. Roof insulation options we have investigated range from R19 to R40 and R40 was selected.

**Shading.** Part of the current marketing strategy for many residential housing developments is to use traditional forms and architectural components which recall a more generous, leisured lifestyle. Vernacular elements such as overhangs, porches, trellises and the like are back into vogue in a large way, and offer both marketing and shading opportunities for the compressorless house. Some shading for both windows and walls comes from the closeness of houses to either side (typically 10'-0"), although this cannot be counted on for a corner lot condition. Extending eave overhangs, which are typically minimal (six inches) in merchant houses, to 3'-0" is specified for additional shading for windows and walls.

**Windows and Glazing.** Window technology has certainly been developed to satisfy all but the shading requirements for residential applications, the only real question is the cost barrier to builders and customers. Low-E and multi-glazed windows are now standard in many markets and "good windows" although commonly understood to be expensive are often also considered a good investment by home buyers. The windows specified for the compressorless house are double-pane windows with low-e glazing, a U value of 0.31

and shading coefficient of 0.43 (solar heat gain coefficient or SHGF of 0.37). This is combined with visible transmission above 0.60, which makes this glass spectrally selective, or cool glazing category, glass that allows most of the visible spectrum to enter while excluding other spectra that increase heat gain. This allows the residents to enjoy the transparency and light without the thermal penalty of this glass, and helps meet California Title 24 energy standards.

**Floor Insulation.** Slab edge insulation for the ground floor slab is provided at R-5 for houses located in hotter inland climates.

## **2. Air Movement**

**Operable windows.** The design of the house incorporates both typical operable windows and takes care to provide paths for good cross ventilation. Natural ventilation is one of the most basic methods for exhausting heat from the house, especially during nights when the exterior air temperature has dropped well below the interior. Open windows can be controlled for security using secure screens, partial opening window locks, and alarm systems. In the two story house designs, open windows on both floors will allow stack ventilation to exhaust hot air from the entire house floor.

**Ceiling fans.** Ceiling fans are specified for each regularly occupied room, including bedrooms and the great room. These do not exhaust heat, but provide air movement during overheated periods, which increases the temperature at which occupants feel comfortable.

## **3. Interior Mass**

Compared to a lighter weight and more exposed Title 24 house, the compressorless house will have cooler interior surface temperatures (a lower Mean Radiant Temperature or MRT) which increase the perceived coolness of the house beyond simply that provided by the air temperature measure. Increased interior thermal mass also helps the house to work like a thermal battery, storing the heat in the mass rather than in the air during the day.

**Walls.** A strategy for increasing thermal mass is increasing thickness or adding layers of gypsum wallboard to both interior and exterior walls. Increasing the mass in interior walls works as a thermal flywheel and external walls with additional mass can significantly delay the thermal impact of high exterior temperatures and solar radiation. All walls are specified with 5/8" gypboard.

In the walls, batt insulation is far less expensive than rigid, however, additional insulation over that which fits into the stud cavity is most easily achieved by applying rigid board over the exterior of the studs. The cost of the rigid insulation relative to improved performance of the walls ruled out the use of this option in the final optimized prototype design except where used as part of the stucco application system. The wall insulation



was specified at R-33.

**Floors.** The second major approach to increase thermal mass is to cover the slab with a non-insulative covering such as stone or tile rather than carpeting and a pad. These finishes can be perceived as a higher quality covering and lower maintenance than carpeting when installed in the right areas. The plans illustrate tile floors in 50% of the first floor.

## **B. HOUSE OPERATION**

The houses are designed to require less cooling than current production houses, however, in order for them to work in climates where it is not economical to rely on envelope design alone, the houses will need additional cooling. This can take a number of different forms based on the amount of cooling that is required by the local climate and the economics of the system proposed. In addition, winter conditions will necessitate some heating. Interior loads have been assumed as 45,322 Btu/day plus three people, coupled with a load schedule based on a series of previous research projects on residential energy use in California.

The cooling strategies and mechanical options vary by climate zone and range from simple window ventilation to mechanical night ventilation. In hotter climate regions farther inland from the coast, the house includes the application of significantly downsized compressors for heat storm periods

### **1. Night ventilation**

In order to exhaust the heat from the day and to pre-cool the mass of the house for the following day, ventilation during night hours is required. For many houses and occupants, manually opening windows to achieve night ventilation is not an option. The house is designed so that the mechanical system can provide ventilation with outside air during the night under a number of system options. Cooling is provided through nighttime ventilation with filtered air and thermal storage of “coolth” in the building mass. Besides saving energy and reducing peak load, this approach is advantageous to those occupants who need to control allergens introduced with outside air and who now rely on compressive cooling to filter the air.

The following mechanical options for providing ventilation cooling systems that respond to all California climate types were explored:

**Option 1. Mechanical Ventilation Using Outside Air.** Cool night air is delivered using the furnace fan and heating duct distribution system. The airflow required for heating is much less than what is desirable for ventilation cooling; to avoid substantial duct oversizing this option limits the ventilation rate to about 0.6 cfm per square foot of conditioned floor area. A damper added to the system switches from indoor air recirculation to outside air ventilation when it is cooler outdoors than indoors.

Option 2. Indirect Evaporative Cooling Pre-cooling. This option augments mechanical ventilation by adding an indirect evaporative cooler to pre-cool the ventilation air. There are currently no residential systems that provide this capability.

Option 4. Small Compressor Cooling. This option employs the use of a small (1.5 ton) central air-conditioner that allows application of the house designs to almost all California climate zones except the hottest regions of the state. A control option could use the air conditioner to pre-cool the house during the night to eliminate operation during peak load periods.

## **2. Controls**

For ventilation cooling to be effective, the occupant must accommodate a comfortable range of temperatures, rather than a discreet thermostat temperature setting that the air conditioner maintains. At the same time, the occupant must be provided with some control over the indoor environment. A controller developed for the house, enables the occupants to have a means of setting upper and lower temperature limits such that ventilation cooling will not operate below the lower limit and air conditioning will run above the upper. The controls design includes an interim design of specially configured off-the-shelf equipment and the design and prototype of an ideal custom controls system. Field tests have demonstrated that the ventilation system and controller installed in a house designed to ACC standards can eliminate the use of air conditioning in the milder regions of Climate Zone 12, which covers Northern California inland valleys.

## **IV. ADVANCED COMFORT CRITERIA FOR ACC HOUSE**

Ideally, the direct adoption of the conditions represented in Figure 5.3.1 in ASHRAE 55 (below) would define and bound the allowable comfort conditions in the ACC house. This figure incorporates some effects of air movement and MRT, as well as recognizing that natural ventilation is part of the cooling strategy:

However, in the Human Comfort Field Studies (Hackett and McBride 2001), one respondent offered that "there's a vast no-man's land between comfort and discomfort." The strategy for an advanced comfort criteria for the ACC house recognizes that acceptable conditions of comfort can be found in that no man's land through adaptive action. Buildings that "tend to facilitate successful adaptive action" incorporate the following approaches: the environment should be predictable and normal (within the acceptable range for that society and climate), thermal variety should be provided as long as occupants can choose their location, and variation should be available, as long as it is chosen rather than imposed. (Humphreys and Nicol 1998)

The proposed criteria include: 1. an ideal set of boundaries (the Adaptive Comfort Standard) and 2. a set operational conditions which facilitate successful adaptive actions on the part of the occupants. If the house interior exceeds the thermal conditions defined

in the Adaptive Comfort Standard, the occupants must have the possibility of achieving comfort in two fundamental ways: through any combination of adaptive activities that the house design and their social context support or by using the mechanical system to bring the interior conditions within the boundaries of the ACS.

**Criteria 1.** The house should attempt to provide conditions defined as 80% acceptability limits in the ASHRAE Standard 55 Adaptive Comfort Standard:

Acceptable operative temperature ranges specified in ASHRAE 55 Figure 5.3.1

**Criteria 2:** If the house cannot achieve the levels of comfort defined in the ACS, the occupant must have *both* of the following options:

**Option 1. Adaptive Actions.** The following adaptive actions are to be available to the occupant and operable under the occupant's choice and control:

- ▮ change of location to a more desirable set of thermal conditions (e.g., migrate to a cooler space in the summer, a warmer space in the winter. This implies that a variety of thermal conditions is available within the house and yard.)
- ▮ change the velocity of air movement (e.g., turn on a ceiling fan, open a window)
- ▮ change the MRT for the following day (e.g., if night ventilation has not cooled the house sufficiently, change the program to decrease the acceptable morning temperature)

**Option 2: Mechanical Control.** There will likely be infrequent periods that the adaptive actions cannot or do not function to achieve comfort for the occupant. This can be due to exterior conditions and/or circumstantial restraints. The house must therefore also have the capacity to achieve the ACS through mechanical means.

## Examples of the Adaptive Opportunities in the ACC House

### 1. Upper Temperature Boundary and Air Movement

The upper bounds of temperature and air movement for summer under the 1994 Standard 55 is about 80 degrees F. at RH 40%, slightly higher at lower RH and slightly lower at high RH. Simulations of performance for the ACC ventilation-cooled house estimate that the indoor temperature will stay at or below 78 degrees F. for all but 0.2% of weather conditions. Thus, for 2 out of 1000 hours, or 17.5 hours per year, the house will experience temperatures over 78 degrees F. This condition occurs as a long run of hot days without a nighttime ocean breeze. In certain parts of the Central Valley and populated foothills, limited hours of ventilation cooling are available, and the indoor morning temperature may start at an actively-cooled 76 or 78 degrees F., not the 65 or 68

degrees required for ventilation cooling to succeed. In this case, some amount of air movement and/or active cooling is required as the day advances.

Moving indoor air at progressively higher velocities will cool the skin to progressively lower temperatures, the same phenomenon as wind chill producing effective temperatures well below the air temperature in a continental winter breeze. The practical limit to air movement cooling is reached when an indoor breeze becomes a nuisance. Working with loose papers at a desk, bathing, or eating might call for slower air movement than relaxing on a couch, cooking, housework, or sleeping. The air movement acceptable in different locations – and at different times in the same location – varies with the kind of activity and the preference of each individual. Each user must be able to easily control the fan speed, and the power and locations of the fans must be sufficient to provide a air movement in continually occupied locations in the house.

We emphasize the importance of providing for air movement greater than 0.8 m/s, at or even above 1.5 m/s, that allows for residents to find additional energy savings and equal comfort by using even higher active cooling setpoints. The ACC inland house will provide air movement cooling to 5.4 degrees F. above the Standard 55 comfort range, or roughly 85.1 degrees F., but the active cooling is [most likely] sufficient to bring the indoor temp down to 79.7 degrees in the absence of air movement cooling. We argue that that residents will use the option of air movement beyond 0.8m/s. Coupled with higher active cooling setpoints, this can further reduce energy consumption. At minimum, active cooling capacity must be sufficient to bring the indoor temperature down to 85.1 degrees F. when air movement is no lower than 0.8 m/s.

## 2. Lower Morning Temperature Boundary for Pre-Cooling

The key to cooling by night ventilation is the use of cool night air to pre-cool the house, basically as cool as the user can accept. Interviews of homeowners living in houses with ventilation cooling tells us that on many occasions, the low set point is not achieved; even if the set point is 65 degrees F., the house may not drop below 70 or 72. Further, when the previous day's outdoor high temperature is moderate, controls designed for the ACC house will moderate the morning low limit temperature, anticipating that morning temperatures below, say, 70 will not be necessary. Regardless, the summer morning temperature is likely to extend below the 73.4 degrees F. prescribed by ASHRAE 55-1994.

We argue that lower temperatures due to night ventilation are likely to be considered acceptable to residents on three grounds. First, lower temperatures are easily adapted to through bed covers. Even when the indoor air temperature is strictly maintained, comfort varies through the sleeping hours: as the residual body heat of the previous day's activity is lost, adjustment by gradually adding bedcovers is needed. In a night ventilation scheme, the change in covers may be greater as the air temperature drops, but in either case (constant temp or night ventilation) an adjustment of covers is required. Once required, the magnitude of that adjustment is of little consequence.

Second, residents will understand and appreciate the results involved in a predictable pattern of lowering the indoor temperature in preparation for the heat of the following day. Third, the pattern of enjoying the coolness of the night in contrast to the heat of the day is strongly etched culturally and physiologically in those areas where there is a significant diurnal swing and low humidity. As Humphrey and Nicol (1998) note, if we understand that a person responds dynamically to their environment in order to find comfort, the environment should be predictable and normal (within the acceptable range for that society and climate). People determine comfort temperatures in close relationship to the temperatures and patterns they experience outside.

## SECTION TWO: BIBLIOGRAPHIES

### I. An Annotated Bibliography on 'Adaptive Thermal Comfort'

The static model of thermal comfort embodied in ASHRAE 55-1992 predicts that comfort is achieved within a relatively constant narrow band of temperature, varying only slightly with the season to reflect clothing preference. Recently, a literature of "adaptive thermal comfort" suggests a considerable degree of adaptation of comfort standards to ambient climate conditions, and that where office building occupants have some control over the thermal conditions, a far greater annual range of temperatures are acceptable. The following articles are included:

**Brager**, Gail S. and Richard J. de Dear, "Thermal adaptation in the built environment: a literature review. Energy and Buildings 27 (1998) 83-96.

**Cooper**, Gail, Air-Conditioning America: Engineers and the Controlled Environment, 1900-1960. Baltimore, Johns Hopkins Press, 1998.

**DeDear**, Richard J. and Brager, Gail S. (1998) "Developing an adaptive model of thermal comfort and preference" ASHRAE Technical Data Bulletin 14(1): 27-49.

**Hackett**, Bruce and Loren Lutzenhiser, "Social Structures and Economic Conduct: Interpreting Variations in Household Energy Consumption." Sociological Forum 6: 449-470.1991.

**Humphreys**, Revd M.A.,(1996) "Thermal Comfort Temperatures World-Wide –The Current Position." WREC.**Humphreys**, Michael A.; Nicol, J. Fergus. (1998)

"Understanding the Adaptive Approach to Thermal Comfort" ASHRAE Technical Data Bulletin 14(1):1-14.**Kwok**, Alison G. (1998) "Thermal comfort in tropical classrooms" ASHRAE Technical Data Bulletin 14(1): 85-101.

**Lovins**, Amory. 1992. *Air Conditioning Comfort: Behavioral and Cultural Issues.* E-Source Strategic Issues Paper. Boulder, CO: E-Source.

**Lutzenhiser**, Loren (1992) "A question of control: alternative patterns of room air-conditioner use." Energy and Buildings 18:193-200.

**Nicol**, J. Fergus; Raja, Iftikhar A.; Allaudin, Arif; and Jamy, Gul Najam (1999) "Climatic variations in comfortable temperatures" Energy and Buildings 30:261-279.

**Nicol**, J. Fergus; Kessler, Maria R.B. (1998) "Perception of Comfort in Relation to Weather and Indoor Adaptive Opportunities" ASHRAE Technical Data Bulletin 14(1):63-75.

**Paciuk**, Monica (1990) "The role of personal control of the environment in thermal comfort and satisfaction at the workplace" Journal of the Environmental Design Research Association 21:303-312.

**Taylor**, Nigel A. S., N. Kim Allsopp, and David G. Parkes (1995) "Preferred room temperature of young vs aged males: the influence of thermal sensation, thermal comfort, and affect." Journal of Gerontology 50A(4):M216-M221.

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**Brager**, Gail S. and Richard J. de Dear, “Thermal adaptation in the built environment: a literature review. Energy and Buildings 27 (1998) 83-96.

Assembles the results of over fifty studies concerned with thermal comfort as a function, at least in part, of “adaptation” to the thermal environment. Whereas research on comfort undertaken in “comfort chambers” shows fairly consistent and similar temperature preferences even across cultures with highly variable climates, studies of comfort “in the field” reveal much more variation, especially in the case of occupants of “naturally ventilated” or “free running” buildings without centralized heating and cooling systems. In the latter case, acceptable temperatures appear to closely lag changes in the outdoor temperature in ways (tracked by but) not explained by behaviors such as clothing changes or the use of fans; persons’ “expectations” seem central: “people grow to accept the thermal conditions they’ve become accustomed to,” in the rather circular formulation. These studies also confirm the importance of persons’ control --real or imagined-- over their thermal environment as enlarging the range of acceptable indoor climates. People working in offices where temperatures are centrally controlled are comparatively very sensitive to minor temperature fluctuations, and the authors speak of the “treadmill” of control: the more centralized the control the more “stringent” the expectations. Control is related to the type of building, with the “free-running” type offering more “adaptive opportunity” than the centrally controlled version (or, almost certainly, the comfort chamber).

**Cooper**, Gail, Air-Conditioning America: Engineers and the Controlled Environment, 1900-1960. Baltimore, Johns Hopkins Press, 1998.

Traces the history of mechanical air conditioning with an emphasis on engineering and mechanical issues, but also details the very problematic acceptance of “man-made weather” among consumers. Accepts Langton Winner’s thesis that technologies are “political” and argues by implication that comfort standards may be highly variable in the population. Air conditioning was resisted in good part because it implicitly attacked the “social rituals” of hot weather –light clothing, cold drinks, vacations, swimming. After 1950, the “passive” climate-control features of homes were often sacrificed to pay for the air conditioner.

**DeDear**, Richard J. and Brager, Gail S. (1998) “Developing an adaptive model of thermal comfort and preference” ASHRAE Transactions 104(1):27-49 January.

Reports on an ASHRAE group effort (RP-884) to develop an alternative to ASHRAE 55-1992 that will account for the adjustment to seasonal highs and lows seen in a number of field studies. ASHRAE 55-1992 assumes comfort is maximized at a constant year-round temperature varied somewhat to account for seasonal changes in

clothing. Outdoor climate and the degree of a building occupant's control over their thermal environment are brought into the mix of factors affecting the proposed adaptive comfort standard.

Adaptive responses to changes in indoor climate are divided into three categories. Behavioral adaptations include changes of clothing, adjusting the HVAC system, or arranging activities during the day to accommodate climate. Physiological adaptations include any unconscious bodily response to repeated exposure to thermal environmental factors that tend to decrease the strain or discomfort resulting from that exposure over time. Psychological adaptation is described as the expectations arising from past experience being altered by repeated exposure to thermal environmental factors, such that comfort in a new indoor climate grows with familiarity.

The objectives were to define adaptive processes; examine semantics of thermal sensation, acceptability, and preference; develop statistical models of thermal comfort based in adaptive processes; compare these models with ASHREA 55-1992; and propose a variable temperature standard. Equations derived from climate chamber studies to predict comfort from these factors without having to interview subjects. Problems arise because lab conditions do not prevail in everyday life, and because people do seem to respond to outdoor temperature and recent thermal experience.

In a mail questionnaire, the authors solicited data, from thermal comfort field studies on occupants of office buildings, gathered by other researchers, with the following requirements. With enough specific data, by standardizing the terms of each measurement, the researchers seem to have created the data quality and internal consistency needed to generate meaningful results. Nearly 21,000 sets of data from 160 buildings in various locations in 11 countries were transformed into common data fields. Particular care was needed to find a common ground for clothing insulation estimates, which were stated by respondents in several forms. Observations were then broken down into types of building (HVAC or naturally ventilated (NV)), and by season. Most NV buildings were studied only in the summer; the exceptions were consistent with the database in that users had some individual control over the heating system, to differentiate them from heating systems in HVAC buildings.

A "semantic effect" is described, such that people in cold weather will profess that they prefer a temperature somewhat warmer than neutrality, and people in warmer weather will prefer a temperature slightly cooler than neutral. This effect is explored by first calculating a "signed semantic discrepancy" from calculated neutrality and stated preferences (the answer to the question "would you prefer a warmer, cooler, or unchanged temperature?"). Results indicate that for HVAC buildings, preferences are one degree warmer than neutralities in winter, and one degree cooler in summer

The authors conclude that occupants of NV buildings accept a wider range of temperatures as comfortable than do HVAC building occupants. Likewise, occupants of NV buildings were found to be tolerant of a wider range of temperature than HVAC building occupants. For naturally ventilated buildings, the gap between the static PMV



model and the adaptive model is only half-explained by behavioral adaptations. Accepting the findings of comfort chamber studies that physiological adaptations within the narrow range of temperatures of a managed building are not to be found, the authors assume by deduction the cause to be psychological adaptation.

**Hackett, Bruce and Loren Lutzenhiser (1991)** “Social Structures and Economic Conduct: Interpreting Variations in Household Energy Consumption.” *Sociological Forum* 6: 449-470.

A study of reactions to a change in the way tenants pay for energy in a California apartment complex revealed that when tenants paid for their own use (rather than sharing the cost to the entire complex equally with all other tenants) their energy-use tended to drop even if their bill was now less than when the cost was the same to everyone. Reduced air-conditioner use accounted for almost all of the reduction in energy consumption, and there were few expressions of discomfort. The findings suggest that the use of air conditioning may have less to do with either cost or comfort than is usually assumed, and that comfort criteria may be quite variable, flexible and adaptive.

**Humphreys, Revd M.A. (1996)** “Thermal Comfort Temperatures World-Wide –The Current Position.” WREC.

A concise summary of the “adaptive comfort” research program, especially the research that compares different cultures as to what people find climatically acceptable (a 15°C difference between Iraq and the UK, for example). An important finding is that people tend to remain comfortable through temperature changes that are seasonal, but that discomfort arises when changes occur within much shorter periods, e.g. a day or week; comfort is then said to be a matter of expectation (though presumably short-term changes wouldn’t all be discomforting: a sunny day during the rainy season might produce “delight” as opposed to mere comfort). Valuable discussion of the conflicting findings of comfort chamber and field studies, suggesting that there are different forms of thermal comfort or that comfort is “context-dependent” or “situational.” Notes the movement toward “dedicated” climates that are tailored to individual persons rather than buildings (cf. the “personalizing” of telephones and automobiles). Also a “political” note –that ASHRAE-type standards tend to impose climates that are much warmer or cooler than many of the world’s cultures find acceptable, with negative economic and environmental consequences.

**Humphreys, Michael A.; Nicol, J. Fergus. (1998)** "Understanding the Adaptive Approach to Thermal Comfort" ASHRAE Technical Data Bulletin 14(1):1-14.

In this article, Humphreys and Nicol establish the conceptual groundwork for the adaptive approach to understanding thermal comfort. They first argue that there is an important difficulty in reconciling the results of comfort studies which use varying research methods: "the comfort temperatures found from the various field studies vary

notably one from another" and are different yet from laboratory results and predicted or calculated results from "rational indices". They speculate that these differences are likely because people work hard to adapt to their conditions, a situation which is not recognized in the models. In response, the authors propose "The Adaptive Model of Thermal Comfort" which states, as a starting point, "If a change occurs such as to produce discomfort, people react in ways that tend to restore their comfort." They identify over thirty possible actions, which fall under five general categories: 1. regulating the rate of internal heat generation, 2. regulating the rate of body heat loss, 3. regulating the thermal environment, 4. selecting a different thermal environment, and 5. modifying the body's physiological comfort conditions.

Circumstantial restrictions are considered to exist as constraints to adaptation. Constraints are identified under the categories of climate, affluence, culture, working conditions and social contexts, thermal control operated by another, personality, fashion, gender and health. "When adaptive actions are constrained by "circumstantial restrictions" (such as not being able to open the window, being required to wear a particular level of clothing, etc.), the result is the particular range of temperatures at which comfort is obtained or not. More conveniently, one can consider the "adaptive opportunity" that is afforded to a person by the building and the social context.

If we understand that a person responds dynamically to their environment in order to find comfort, design and building for comfort can incorporate approaches that "tend to facilitate successful adaptive action": the environment should be predictable and normal (within the acceptable range for that society and climate), thermal variety should be provided as long as occupants can choose their location, and variation should be available, as long as it is chosen rather than imposed.

The authors also identify climate and expectations related to conditioning capabilities as two major contributors to the determination of a comfort temperature. People determine comfort temperatures in close relationship to the temperatures and patterns they experience outside. People also develop very different expectations of comfort relative to whether the building is totally controlled by a mechanical system, naturally ventilated, or "free-running" with no mechanical conditioning and therefore very little freedom of choice or control of temperatures at all.

**Kwok, Alison G. (1998) "Thermal comfort in tropical classrooms" ASHRAE Technical Data Bulletin. 14(1): 85-101.**

This paper presents field studies carried out in Hawaiian schools which examine the applicability of comfort criteria for tropical classrooms. The authors used survey questionnaires, physical measurements, interviews and behavioral observations to collect data in 29 naturally ventilated and air conditioned classrooms. The majority of the classrooms failed to meet the physical specifications of Standard 55 comfort zone, however the acceptability votes by the occupants of both naturally ventilated and air conditioned classrooms exceeded the 80% criteria, regardless of whether the physical conditions were in or out of the comfort zone. One of the few adaptive mechanisms available to students was levels of clothing, and this was typically adjusted not only seasonally, as predicted, but during the course of the day to move between air conditioned spaces and the outside.

**Lovins**, Amory. 1992. *Air Conditioning Comfort: Behavioral and Cultural Issues*. E-Source Strategic Issues Paper. Boulder, CO: E-Source.

In this report, Lovins reviews and summarizes research on comfort and cooling, drawing extensively on papers in the Kempton and Lutzenhiser special issue of *Energy and Buildings* [*Air Conditioning: The Interplay of Technology, Culture and Comfort* 18(3), 1992.], but also supplementing that collection with key work from the comfort studies literature. Lovins identifies four distinct, often contradictory, sometimes complementary, commonly used “comfort paradigms” that he terms the electric-utility, engineering, economic, and social sciences paradigms. The report is primarily concerned with how anomalies in the dominant engineering comfort model and findings from comfort field studies and social science research raise questions about its validity. This is important, Lovins argues, because buildings built and HVAC systems sized using that model are likely to routinely waste a considerable amount of energy with serious energy system and environmental consequences.

The conventional comfort model treats thermal neutrality (essentially a state of being neither warm nor cool) as a physiologically desirable condition that persons will “naturally” identify as the most comfortable. This model was derived largely from P.O.Fanger’s laboratory experiments in the early 1970s, in which persons were subjected to changing environmental conditions in a carefully controlled “comfort chamber” and asked to periodically note whether they believed that they were, at that moment, either too warm or too cool. The votes of samples of experimental subjects were averaged in order to estimate an optimally comfortable temperature with a small range of acceptable temperatures around it. Researchers pursuing these controlled environment studies believe that the thermally neutral state is physiologically determined and quite similar for all persons. The ASHRAE guidelines for the design of HVAC systems in commercial and institutional buildings embody this belief, offering a series of equations that are intended to assure the least discomfort for the greatest number.

Lovins’ conclusion from his review of the literature is, however, that the conventional comfort model is seriously flawed. By basing the ASHRAE design standards on this model, resulting systems may not assure optimal comfort and energy will be unnecessarily wasted in the process.

Lovins discusses the comfort chamber research in some detail, and then launches his criticism by pointing to a surprisingly wide range of comfort temperatures reported in tables included in Fanger’s own seminal work (although not remarked upon in that text). The ideal of the universal comfort temperature posited by laboratory researchers is, in reality, a statistical mean around which personal preferences seem to vary widely. Building on this observation, Lovins proceeds to introduce a variety of findings from field comfort studies and behavioral research that reinforce the idea of variability across populations, as well as within the experiences of individual actors through time, across

different social contexts, as a result of interaction with technologies, and as a function of the ways in which comfort questions are posed by researchers.

Even seemingly innocent variations in physical surround can produce provocative results. Lovins notes that in the course of one climate chamber study researchers needed a second chamber, and chose to convert a used meat locker to their use. Subjects consistently perceived the temperature to be cooler than the first chamber, when in fact the temperatures were the same. The researchers redecorated the locker with wood paneling, carpet and acoustic ceiling tile, and the difference in perceived temperatures disappeared.

Differences between chamber and field studies are significant. Field researchers have repeatedly found that persons in real settings (mainly offices, where the comfort criteria are most frequently applied) report experiences, preferences and tolerances ((e.g., warmer in summer and cooler in winter)—and differences from one another in these—that are quite different from what the comfort chamber-based studies would suggest. There is ambiguity here, since many field studies suffer from limited measurement of key variables. However, a key field study by J.F. Busch (“A Tale of Two Populations: Thermal Comfort in Air-Conditioned and Naturally Ventilated Offices in Thailand.” Energy and Buildings 18(3): 235-49. 1992) using careful comparative design (e.g., comfort reports from both mechanical air conditioned and naturally ventilated workplaces) found significantly higher reported comfort temperatures in the non-AC settings. Lovins notes that within office settings, a wider range of temperature preferences, coupled with different social norms governing dress (e.g., of men and women) often result in “thermostat wars,” less than satisfactory efforts by building managers to lock up the AC controls, and systematic differential impacts in over and under-cooling.

Studies of actual temperature preferences and air conditioner usage within households also reveal differences in preferences and a tremendous amount of variation in thermostat settings and AC operation patterns. Based on these findings, Lovins argues that while the application of the chamber-based models to offices may be problematic, their application to households is completely inappropriate.

Lovins also considers research on variability within the experience of individuals in terms of their reported comfort preferences and tolerance for heat. There is evidence, for example, that persons learn to expect particular temperatures as appropriate to particular sorts of places (offices, theaters, churches, malls, homes, indoors vs. outdoors, etc.). Those expectations are, of course, learned and not innate, and persons appear to be quite willing to tolerate quite different environmental conditions in different settings—as long as conditions are appropriate to those settings.

Citing work on “semantic effects,” Lovins also points to findings that persons provide significantly different assessments of comfort under the same conditions depending on whether they are asked to supply information on their “preferences,” “comfort,” “discomfort,” etc. These results also point to a situational character of comfort that is socially learned, socially regulated and socially reported.

Along with variability among persons, within persons' own experience, in expectation across contexts, the literature also suggests variability in comfort standards through time. Lovins cites evidence of physiological adaptation (acclimatization, habituation) to heat and hot climates, as well as "addictive" affects in some cases of exposure to air conditioning. He also points to research findings of psychological adaptation in the form of changing expectations, and a range of routine behavioral adaptations, including: window management, fan usage, clothing, strategic use of air conditioning (including a variety of AC use strategies that involve creative control of AC units in ways unanticipated by their designers). He concludes with a discussion of the importance of control (and perceived control) in comfort experience and heat tolerance.

**Lutzenhiser, Loren (1992)** "A question of control: alternative patterns of room air-conditioner use." Energy and Buildings 18:193-200.

Families renting University owned on-campus apartments at UC Davis were interviewed, and asked whether they used manual or automatic controls on their wall unit air conditioners. The apartments had recently converted to individual metering and billing, so the subject families paid for the energy used. Manual control (59% of users) implies cooling-on-demand, and cooling of people, whereas using an automatic setpoint (29% of users) implies keeping the central living room at no higher than a given temperature, the cooling of the space. The majority of automatic users used high setpoints, which follows a space cooling strategy while moderating costs.

Interviews revealed a variety of control strategies that reflected basic misunderstanding of allow a longer period of noise-free comfort. The influence of noise is not explored, but operating these AC units produce a substantial rattle and hum, much more bothersome than a box fan.

A short discussion of the consequences of air conditioning provides some quotes that may be revealing, e.g. "we don't use the AC because it makes it too hot outside," and "We didn't have AC when we were kids. It wasn't so bad, you just got used to the heat."

For the most part, the use of AC in these apartments as direct cooling of people may have been part of a cost-reducing strategy, since space cooling to, say, even below 80 degrees with these units was prohibitively costly for a family supported by a graduate student. Making the units cool can be hard and the coolth quick to dissipate, due to undersized and inefficient AC's and poor insulation. Placing a box fan near a room AC provided better mixing of cool air, and no doubt increased the cooling sensation. Avoiding the indoors by using the library or patio and barbeque from about 4 to 9 p. m. was a common strategy.

**Nicol, J. Fergus; Raja, Iftikhar A.; Allaudin, Arif; and Jamy, Gul Najam (1999)** "Climatic variations in comfortable temperatures" Energy and Buildings 30:261-279.

Two studies examine comfort among subject occupants of a group of office buildings in each of the distinctly different climates of five Pakistani cities. A simpler first study using a small sample was reformulated and applied using over 800 subjects and monthly data gathering over one year (1995-96).

Altitude, humidity, and temperature vary widely across these five cities, encompassing coastal tropics to mountainous then arid subtropics, and humid and sub-humid continental climates. Clothing varies substantially, both as a function of cultural differences and seasonal climatic variation. More than 80% of the subjects were comfortable between 20 and 30 degrees C., across all five cities and all seasons. Over 80% of subjects in Multan, in the hot arid region, were comfortable if the temperature was less than 33 degrees C.

The goal of the studies was to contribute to the setting of a new adaptive standard for Pakistan. Results of the field studies are employed in specifying those standards. Heat balance and adaptive models are tried as different ways of predicting comfort temperatures. Outdoor temperature is judged to be the most practical prediction tool. The qualitative difference in comfort between buildings having HVAC systems and naturally ventilated ones seen in other studies is absent here. Perhaps having an HVAC building is no guarantee of constant temperature where energy supplies may be limited or intermittent.

**Nicol, J. Fergus; Kessler, Maria R.B. (1998) "Perception of Comfort in Relation to Weather and Indoor Adaptive Opportunities" ASHRAE Technical Data Bulletin 14(1):63-75.**

In this paper the authors present the case study of occupant satisfaction over time in a building which has a naturally ventilated open plan floor, a naturally ventilated floor with cellular offices and mechanically cooled floor with both open plan and private office areas. The results show a clear change in the perception of comfort and the available adaptive opportunities as the weather cools down from an exceptionally hot summer. Crucial conclusions from this one case study include: 1. Comfort cooling is superior to natural ventilation during the hottest parts of the summer. 2. Despite being open plan, the naturally ventilated first floor is considered the most satisfactory. 3. first floor occupants who are not near a window, and therefore have less control over their environment, are less satisfied. 4. Thermal comfort and self-assessed productivity are dependent on the level of control that people feel they have over their environment and the mean temperature during office hours. 5. The temperature above which comfort is badly affected is lower than the temperature at which productivity is badly affected. 6. Occupant perceptions of a building change as their thermal priorities change. For example, when the weather was extremely hot in August, being cool was the most important part of building satisfaction, whereas when the outside weather had cooled

down, people looked at other aspects of their environment to determine levels of satisfaction with the building.

**Paciuk, Monica (1990)** “The role of personal control of the environment in thermal comfort and satisfaction at the workplace” Journal of the Environmental Design Research Association **21**:303-312.

Thermal comfort is reconceived in terms of a situation specific process by which individuals strive to attain a goal whose meaning and value is constantly defined and redefined in the light of their personal resources. Personal control of the near environment is shown to intervene between environmental stimuli and thermal comfort.

Occupants of ten office buildings in Haifa, Israel were studied during winter 1986, with the intention of clarifying how thermal comfort is regulated using mechanisms of individual control over the thermal environment. Physical measurements, observations, and, structured interviews were used to gather data, which was analyzed in two stages: variables representing thermal conditions and comfort-related outcomes, and those representing perceived control over the thermal environs. A path analysis shows strong relationships between perceived control and satisfaction. Two subsequent models of the influence of control-related factors show that perceived control over the thermal environment even when all other factors remain in the model. Unlike the conditions in the Pakistan field study here reviewed, most subjects were able to achieve comfort, similar to conditions in California.

**Taylor, Nigel A. S., N. Kim Allsopp, and David G. Parkes (1995)** “Preferred room temperature of young vs aged males: the influence of thermal sensation, thermal comfort, and affect.” Journal of Gerontology **50A**(4):M216-M221.

This climate chamber study was intended to compare the thermal responses of two age groups as a means to help understand the death rate of the aged as related to hypothermia. During the Australian autumn-almost-winter (May to June), a group of twentyish and a group of sixtyish Australian males were given a standardized introduction to the project and how the devices work. The subjects change into a standard set of loose shorts and open sandals, enter a chamber provided with a reading table, reading material and a two position switch, and are wired into their chair. The starting temperature is around 82 degrees F. Thirty minutes after entering the chamber, the cooler is turned on. The switch is marked “warmer” and “cooler”, but is not supplied with an “off” switch. Subjects were instructed to keep themselves as comfortable as possible.

The older group endured colder limbs under cold stress and warmer limbs under heat stress for a longer time before adjusting temperature than did the younger group. Both age groups adjusted around the same average temperature.

The purpose of the experiment was to measure a response to stress, but the stress created was not a mimic of everyday life. Far afield from thermal comfort, this study may have nonetheless illustrated that age groups respond differently. The game-like setting may have caused the two age groups to seek different motivations, perhaps because the reading selection captivated one age group more, and they wanted to read rather than be distracted flipping a switch. The study does suggest the value of examining responses to thermal conditions across human characteristics, variation oddly neglected in most thermal comfort studies.



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# **HUMAN COMFORT FIELD STUDIES**

**Bruce Hackett, PhD**

**Robert McBride**

**October 2001**

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# **HUMAN COMFORT FIELD STUDIES REPORT**

## **Alternatives to Compressor Cooling Project**

**Contract No. 500-98-024**

### **Task 2.3.5 Deliverable**

## **Background**

Though much research has been completed to develop an understanding of comfort in commercial building settings, little is known about the variety of comfort perceptions of people in residential environments. This report documents the results of qualitative field research on how people define comfort in residential settings, thermostat use, and the use of windows and mechanical devices to improve comfort.

## **Scope of Interviews**

In the summer of 2001 (primarily mid-August through September) Bruce Hackett and Bob McBride conducted 50 interviews in two central valley residential locations. Thirty were completed in Davis: 25 in the city's new "south" development and 5 in the new and upscale North El Macero subdivision where the homes are equipped with night venting systems. Twenty were completed in Gold River, an unincorporated suburban area east of Sacramento. Seventeen were in Gold River Station, a four-year old subdivision, and the remaining three were among two fifteen-year old upscale planned 'villages' of Gold River. A list of questions, included in Appendix A, were used as a guide for conducting the interviews. The interviews took approximately an hour each and were concerned primarily with persons' stated thermal comfort desires and the ways in which they manage their homes in dealing with the summer heat. In all of these settings the homes are rarely over 6 years old, and the residents are almost without exception white, young (30's and 40's) and employed in middle-class white-collar occupations.

## **Interview Summary**

### ***Thermostat Settings and Temperature Preferences***

Respondents were asked about their thermostat settings and about the "range" of temperatures that they both desired and that they would tolerate. Given the social homogeneity of the populations studied, there appears to be a considerable spread, a large amount of variation, in the preferred and tolerable temperatures, as reported in Tables 1 and 2.

**Table 1: ‘Ideal’ and ‘Tolerable’ Temperature Ranges for 30 Interviewees in 21 Homes in Davis, California, Aug-Sept 2001\***

Low Ideal	High Ideal	Low Tolerable	High Tolerable
60 (5)	72 (1)	50 (1)	78 (4)
62 (1)	74 (3)	55 (2)	80 (6)
65 (1)	75 (1)	58 (1)	81 (1)
66 (1)	76 (4)	60 (4)	82 (2)
68 (2)	77 (1)	64 (2)	85 (4)
70 (2)	79 (1)	65 (1)	86 (1)
72 (1)	80 (11)	70 (2)	88 (1)
73 (1)	82 (1)	72 (1)	95 (2)
74 (1)	85 (1)	73 (1)	98 (1)
75 (3)	90 (1)	74 (1)	
76 (3)		75 (1)	
77 (1)		76 (1)	
78 (1)		78 (1)	
79 (1)			
Mean = 69.8	Mean = 78.6	Mean = 65.2	Mean = 83.6
Total N = 24	Total N = 20	Total N = 22	Total N = 25

\* Total N’s vary because the two ranges could not always be distinguished from interviewee responses. N’s at individual settings are in parentheses.

**Table 2: ‘Ideal’ and ‘Tolerable’ Temperature Ranges for 20 Interviewees in 14 Homes in Gold River, California, Aug-Sept 2001\***

Low Ideal	High Ideal	Low Tolerable	High Tolerable
65 (1)	75 (6)	55 (2)	77 (1)
70 (1)	78 (6)	60 (8)	79 (1)
72 (1)	79 (1)	65 (4)	80 (4)
73 (1)	80 (3)	66 (1)	82 (4)
74 (1)	81 (1)	68 (1)	83 (4)
75 (5)	82 (2)	70 (2)	84 (2)
76 (3)		72 (1)	85 (3)
77 (1)		75 (1)	90 (1)
78 (4)			
79 (1)			
80 (1)			
Mean= 75.2	Mean= 78.0	Mean= 63.6	Mean= 82.4
Total N = 20 for all categories			

\*Values were inferred in a few cases from responses to other questions in the interview. Values of 55 and 60 degrees in the “Low Tolerable” column were inferred from people who stated they opened windows regularly at night and rarely closed them because of the cold.

There is as well a virtually routine and almost predictable division of thermal preferences -- sometimes acrimonious -- even within households; in almost every case spouses' preferences were not the same, with the men twice as likely as the women to prefer it cooler than their partner (see item 2 in Appendix B, "The Questions and the Code," below). This is consistent with the findings of studies that have measured energy consumption within socially homogeneous areas (e.g. all of the homes in a single city block). It is important to note, however, that what is reported here is talk about temperatures and comfort. The requirement, encased in the questions asked, that respondents offer numbers (when their orientation is in fact more nominal or ordinal than integral, or more narrowly biological than cultural) may be conducive to a degree of variation that is apparent rather than real. Of course the opposite might also be true; sociology as a craft is fond of viewing the social world dramaturgically, emphasizing the work done by persons to mask or "present" themselves in the trappings of "normality," as when speaking to an interviewer and perhaps especially during an 'energy crisis'. This should contribute to restricting rather than enlarging the range of apparent variation.

The sample of households studied for this report might justifiably be socially and economically homogeneous because it probably comes close to representing the population of recent and current new home buyers in the California central valley. However, a larger and more diverse sample would help to put this group in perspective, a fact hinted at in the few interviews below conducted with persons who grew up in other cultures (Mexico, Korea, India, the Philippines).

Assuming that the variation shown here is not wildly at odds with the "true" rendering of temperature choice in this population, the meaning of the variation is itself potentially variable. The boundaries of an individual's "comfort zone" may be highly determined, firmly embedded over time in that person's self-conception, perhaps a routinized response to repeated injunctions to "make yourself comfortable." But the choices might also be fragile and to a considerable degree arbitrary, in which case the variations noted here could indicate the potential for "thermal adaptation" in this group -- a range that perhaps tracks the modal diurnal temperature swing of a central valley summer day and night.

The notion that temperature preferences may have considerable elasticity both within populations and for individuals -- and that people hesitate to describe comfort in numerical terms -- seems congruent, at least, with the fact that very few of those interviewed "program" their thermostats<sup>1</sup>: only 5 of 27 do so exclusively; 17 prefer "manual" operation and the other 5 do some of both. These figures are consistent with PG&E load-shape data that show dramatically that a large proportion of central AC users, perhaps as many as 2/3rds, continuously adjust and re-set their systems in reaction to real or perceived climate changes and building performance. The preference for manual operation may reflect the fact that people think of the thermostat as a valve, but it is also likely that the actual making of one's self comfortable is, alongside being comfortable, an activity thus far neglected in our effort to understand the dimensions and the doings of thermal well-being.

In formulating the questions for this report we favored open-ended discussions that would establish some comparability but allow the interviewees some latitude in framing the issues. We tried to distance the research from the "crisis" in the background

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<sup>1</sup> Taken from Davis interviews; this is also consistent with Gold River interviews.

("This project has been underway for six years") and to avoid -- unsuccessfully, we thought, in a few cases -- giving our respondents a sense that they were taking a test, since that sense might encourage persons to compromise comfort, at least verbally, in favor of conservation. While this effort to make people comfortable in expressing their desire to be comfortable may have made a valuable contribution to the cause of candor, a close reading of the interview write-ups raises the question of whether 'comfort' itself is really a salient issue for many people, at least under many if not all circumstances. As one of our respondents put it, "There's a vast no-man's land between comfort and discomfort," suggesting that comfort and discomfort alike become matters of concern only at the margins of everyday experience. This is one way to interpret the fact that in many of these homes the temperature is lowered when guests are anticipated.<sup>2</sup> Thus, comfort can be seen as a requirement of social, perhaps even 'public' occasions or gatherings (though of course among staunch environmentalists the absence of air conditioning or a high thermostat setting might be considered praiseworthy). We think it also significant that in many cases our interviewees seemed fatalistic rather than seriously annoyed about the fact that their homes' second stories were much warmer than their 'comfort zone' would allow in the afternoon and evening. Most of the homes in our samples are two-story and on lots which are small relative to older suburban developments, and they have an upstairs heat problem" in the summer. This sentiment might, of course, also reflect an understandable desire to play down the 'design flaws' in their most expensive recent purchase, or even be the kind of shared fate that enhances neighborhood solidarity.

### ***Understanding of Comfort Systems and Natural Ventilation***

The possible low salience of comfort as an issue may also be related to the fact that almost none -- less than 10% -- of our interviewees knew either the brand or the tonnage of their air conditioners. Nor did they know about the home's insulation, neither as legally required nor as reportedly installed. Moreover, a separate study of window-openings in Gold River by McBride (see Appendix G) seems to show that opening the house at night is not only an underutilized cooling resource but also an "occasional" rather than regular or systematic activity on the part of most of those who do it. But we also reasoned that a concern with comfort --and not just one's ability to achieve it-- might itself be a function of one's knowledge of how the comfort-producing equipment (including the house) "works," and our sense from these talks was that "house knowledge" in these settings is very limited. There may also be other (and historically emergent) concerns that may "upstage" comfort (and conservation as well). A concern with security is almost universal, and all but one among over 120 households that opened their houses at night limited this to the upstairs windows. Others cited freeway noise or neighborhood noise as a reason to keep their windows closed.

Thus we see in these reports some reason to be cautious about assuming either high levels of concern with comfort or inflexible comfort -- preferred temperature -- criteria. Yet it is also important to make sure one is looking in the right place; for example, the nearly unanimous enthusiasm for ceiling fans expressed in the interviews --

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<sup>2</sup> This is one of the few ways in which Davis and Gold River differed; item 3 in Appendix B, below, reports that three-fourths of Davis respondents reported this practice, one-fourth in Gold River, implying that those in the Davis sample may be slightly more willing to keep their "personal" temperatures higher.

including, in several cases, an expressed desire for more of them -- combined with several negative comments about air conditioning in general surely lends support to current efforts to upgrade the importance of air movement, rather than temperature alone, in providing comfort. Many people are enthusiastic even about the sound of the fans -- a neglected aural component to comfort, perhaps. Moreover, one of the leads to be followed from these reports is the possibility that people do not treat the technologies of comfort as “neutral” but rather make invidious distinctions between them, so that we can speak of comforts of different types -- air conditioning can be “magical” to some but fans and air movement (or even “fresh air”) the comfort choice of others. The same can be said for technologies not directly related to comfort; we were somewhat surprised, for example, by the nearly universal enthusiasm, in these households, for photovoltaics. The technologies that people “prefer” are also invidiously status-ranked in the larger social and cultural world -- air conditioning is to evaporative cooling for some as the refrigerator is to the icebox -- so that “neglected” technologies such as evaporative coolers (among this sector) or clotheslines (among a broader sector) can be set aside for reasons that people find difficult to acknowledge.

## Conclusions

We urge readers of this report to take the time to read the individual interview write-ups included as Appendices E and F, not just this summary and Appendices B, C and D, “The Questions and the Code” and the “Observations” in order to appreciate the real texture of these conversations. In our understanding of them, these data show some considerable range in the collective comfort zone and probably indicate considerable adaptability in individual thermal preferences, which seem to be “situational” rather than fixed; they indicate the importance of “manual” climate control and air movement; they raise questions regarding the salience of comfort as an issue, compared with other concerns; and they suggest a possible relationship between comfort and knowledge, the latter as source of comfort as a concern and as a means of providing it. We also note here the unwanted datum that even in environmentally “progressive” communities homes are still being built in which the air conditioner is -- as one architect noted in an earlier phase of our ACC research -- “a prosthetic device,” a device used to remove the heat that should not be there in the first place.

## Appendix A - Interview Guide

### ***Questions Regarding Cooling-Season Comfort***

Our aim in this research is to better understand the indoor climates that are comfortable to people in their homes during the warm summer months. Improved understanding of comfort (and the sources of discomfort as well) can aid in the design of homes that minimize the costs of comfort without sacrificing its quality.

1. How long have you been living in your current home? Type of house?[stories, age, size]
2. The occupants? (age, gender, occupations)
3. Is there an air conditioner, and if so, do you use it? Is there a 'typical' pattern of use that you can describe, or does it vary from day to day? What thermostat settings? Does the house have more than one 'zone'?
4. Are there other things that you do for cooling --the use of ceiling fans, for example. Vents? Opening the house at night? 'Personal' things like clothing changes? Are there typical procedures here as well? (If you don't open the house at night): Is this for security reasons?
5. Are there differences in the family as to temperature preferences, or the way in which cooling is obtained? Does one person (which?) control temperature settings? Is there ever any conflict here? [Do you have a 'programmable' thermostat? (If so:) How do you use it?] [Is there any difference between your 'ideal' setting(s) and the setting(s) you actually use?]
6. How would you say your approach to cooling compares to that of your friends, neighbors or co-workers? Do you think of yourself as average, or typical?
7. (If AC is used): Would you happen to know the size (EER? brand? year?) of your air conditioner? Are you pleased with this AC or would you prefer a different model? Do you know your insulation levels?
8. I asked before about thermostat settings. Now let me ask you if there's a range of temperatures within which you think you'd be comfortable. What would your warmest temperature be? Would this vary depending on the use of fans, or perhaps on what you were doing? What is the coolest/warmest you would allow the house to be?
9. Do you ever vary or change the temperature of your home if there are guests arriving (including other members of the family who don't live here)? What change do you make?
10. Do you work outside of your home? (If yes): Do you think your comfort requirements in the workplace are the same as at home? If not, how do they differ? Are you satisfied with the temperatures that are maintained at work? Are employees involved in determining the temperature settings?

### **General Perceptions About Energy Use**

Other aspects of this research (work on new house designs, for example) began over five years ago, so the research is not directly related to California's current energy situation; but since our work is clearly energy-related, I'd like to ask you a few questions about your perception of that situation.

1. Do you have a judgement about how serious you think the current energy problem is? About who or what is responsible, if the situation is serious? And about what ought to be, or likely will be, done about it?
2. The Sacramento Bee has recently carried a series of articles on devices that reduce energy consumption, but which are also often controversial for aesthetic, practical or economic reasons. Do you personally find any of the following attractive, and would they be useful in your own situation?
  - a. Clotheslines (as a summer substitute for the electric clothes dryer)?
  - b. Evaporative (or "swamp") coolers (substituting for the air conditioner)?
  - c. Photovoltaics --to produce a portion of the home's own electricity use?
  - d. Other energy-conserving equipment is available, such as whole-house fans, solar shade screens, and additional insulation. Have you added any of these since you moved into your house? Have you added any this year? [Or considered such additions?]
3. California residents have been widely urged to reduce their energy use to the extent possible, and media campaigns both by the state and by private corporations have had numerous suggestions for how do to this. Have you had any interest in this and have the suggestions had any applicability in your own case?



## Appendix B - Questions and Coding

These are the items that were emphasized in coding the interview protocols, including the number of answers obtained for each choice. In parenthesis, the number of Davis responses are followed by a comma, then the Gold River responses.

1. Is the AC operated manually (17,12) or programmed (5,2) or some of both (5,3)?  
Hard to code in some cases (“some of both”).
2. Is the one (among couples) who prefers it coolest the husband (14,8) or the wife (7,2)?
3. If guests are expected do they lower the temperature (15 of 21, 4 of 15 homes)?
4. Number of ceiling fans (number of homes in parentheses): 0 (3,1), 1 (2,2), 2(4,0), 3(6,7), 4(4,0), 5 or more (2,4)
5. Open Windows: evening only (3,3), morning only (4,1), night (10,14) no (4,2). Open upstairs only? (4,9) (needs re-checking). Downstairs mentioned as opened? (\_\_,4)
6. Know about AC brand, tonnage, insulation: 3, cases in Davis. In Gold River, knew brand: 6 cases; knew tonnage: 2 cases.
7. Compared to neighbors: R is typical (5,9), R sets temp lower or uses less energy (3,4), R sets temp higher or uses more energy (9,3), Don't know (4,0)
8. Are clotheslines acceptable? Yes: (21 of 28, 9 of 18). Swamp coolers? (5 of 24, 12 of 15). Photovoltaics? (19 of 24, 14 of 16).
9. ‘Ideal’ and ‘Tolerable’ temperature ranges or zones: see separate table in the report text.

## **Appendix C – Observations and Quotes from Davis Interviews**

These observations were culled from the interview write-ups. The write-ups themselves should be read for a full appreciation of the variety of cooling strategies and the substantial variation in comfort requirements even within a demographically rather homogeneous setting. All 30 of the interviews (in 21 homes --husband and wife were both interviewed whenever possible) took place in Davis, two-thirds of them on a single block in south Davis.

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Diversity: two Davis neighbors, both men of the same age, turn on AC at 5, both set it at 81; one runs it for about a half hour, the other until 11 p.m.

Some use the thermostat not to produce but to indicate their comfort. One man turns on his AC at 5:30 a.m. to try to get the house down to 70; if he can't get it that low he'll put a box fan in the doorway and "aim" it at the thermostat, "so I fool myself."

The same man said "I like the AC but I also like to keep it off." But he also admitted that he's glad he can't control the temperature of his office at work, which is cooler than he keeps his house, because then he'd feel an obligation to keep it warmer.

Grown sons keep house open all day when visiting, even when temp over 100 because "they demand fresh air."

Many very small conservation measures to establish the principle: foregoing cooked cereal, reducing use of pool sweep, "turning stuff off," using candles at dinner, relying on watches rather than electric clocks, taking cooler showers. One woman thinks a lot of conservation is "symbolic. You make a statement when you have 'em but don't use 'em."

Teacher asks for top floor classroom when temperature set at 78 and she's too cold, worries that her preference will make it too hot for the students.

Couple uses their own discomfort to indicate when to turn on the AC "because we're cheap," then sometimes overreact, set it too low. Thermostat as 'valve?'

Many reservations about AC --"it's fake air," and "I hate AC; I don't want to spend money to freeze myself," and one man said that air conditioning made him feel like was "in a diving bell"-- but no reservations about fans; one can hardly have enough of them. Several like the sound of the fan(s) and the moving air, and a few feel that the fans, not the AC, are the real key to comfort, though for one interviewee the fans are mainly "for the in-between season." One man argued that he had an aversion to AC because of his allergies and that "one can't be casual about it if you have an aversion to air conditioning; it has to be medical or moral, strong feelings."

There can be an “AC effect” independent of its effect on temperatures: a woman said that her house “feels cooler when the AC is at 80 than it does when the house is 80 with no AC.”

Woman says her recently deceased husband, though not herself, knew how to program the thermostat, “but even when he was alive we just set it where we wanted it at the time; in fact [we] like to set it.”

For some, being cool is mainly for sleep.

A woman says that 72 degrees is simply too cold for her, but if the house could be gotten down to 60 at 6 a.m. “that would be great. Even 55 would be fine but that’s not real.”

Efficiency as excuse to get new equipment: one respondent has a friend who replaced her freezer, dryer and refrigerator all on the same day. With a focus on conservation appliances become moral agents: “The only bad thing here is the stand-up freezer.”

Conservation as sportive: “It’s kind of fun, seeing how low you can get your bill.” Another person likes the idea of thinking of reducing the energy bill as a “game.”

Comfort as social and situational: most people reduce the temperature when guests are arriving, though it may matter where guests are coming from and their ethnicity (see interviews). Man likes to stay quite cool “but when it’s ok to sweat I’m not so concerned.”

Using AC to prevent using it: “Many people I know run the AC all the time. Some feel that it saves money to make the house stay cool, at, say, 77, and not let it heat up.”

Energy crisis as a blessing: woman “flees” cold office to car, parked in the sun, “for a sauna; but this year we had a blackout and I thought it was wonderful.” Others who dislike AC used the energy situation to legitimate doing what they wanted.

Conservation vs. security: by far the main reason given for keeping the house closed, especially on the ground floor, is security.

Dedicated evaporative coolers: one woman says that she keeps a hair-spray bottle with water in it handy and “mists” herself with it to stay cool; another (not an interviewee) says that she has no AC and occasionally gets in the shower with her clothes on; “It lasts about an hour, maybe awhile longer.” But another woman who lived for several years in another home in Davis without AC and took frequent cold showers says that in her new home she thinks the air conditioning is “magical.”

One man stays cool on hot days by lying on the cement floor in the garage, or putting his feet in ice water in the sink. “Sometimes when I’m too hot at night I’ll go to the sink.”

Cultural comparisons: a man visiting from France, father of an interviewee, asks why there are so few shutters here, the walls so thin, and says “You have so much sun here -- why is there so little solar energy?” A Mexican-American interviewee who grew up in Mexico says that he dislikes air conditioning “whether it’s heat or cool” and says that “In the states people make it too hot or too cold, and then you get allergies.” A couple uses the fact that they both “grew up in the Philippines” to explain the fact that they keep the downstairs windows open during the day.

A man complains that the low ceiling in the upstairs bedroom (“you can touch it with your hand”) makes a person feel “squeezed” and makes the room “feel even hotter” than it “is.” A woman says that the many stuffed animals and dolls that she collects and has in her home augment the “stuffy” feeling in the house when the temperature gets over 80.

A woman who works as a dental assistant says that at work they set the AC to 74 because of the lab coats “and the AC runs all the time. All of the women patients say it’s too cold.” An MD who works in a medical clinic in Sacramento and thinks the clinic is much too cold noted that “menopausal women like it.”

One woman whose upstairs stays quite warm said that she had tried sleeping on the kitchen floor “but I was attacked by ants.”

One man offered what might be a useful qualifier to the notion of a “comfort zone” -- “There’s a vast no-man’s land between comfort and discomfort.”

Five of the interviews were conducted in four homes equipped with SmartVents; in only one of the four homes was this equipment used properly from the start, and in two of the other three homes there is still confusion and problems with the vent’s use. In one home, when the vent goes on this is used to indicate that it’s ok to open the windows.

One man said that he and his wife were “into Feng Shui and I’m not sure how that would impact [the pursuit of efficiency]. Maybe Feng Shui would be efficiency. But if I had to choose between Feng Shui and efficiency I’d choose the former.”

A woman who lives in the upscale north El Macero area complained with some emphasis about the fact that her house and those near her had “too many windows. If you see the new design of homes there are tons of windows on every side to let in light. I suppose this saves us on light bulbs but in the hot California summer it’s akin to living in a hothouse.”

## **Appendix D – Observations and Quotes from Gold River Interviews**

Gold River Station (the subdivision most of those interviewed in Gold River live, in turn, has many residents who moved from outside the region, and many who work in electronics, especially for large high-tech firms like Intel and HP. The Gold River Station population is uniform by economic classification, but diverse, especially of recent immigrants. We interviewed people from India and Korea, as well as domestic-born people who grew up in a household where English and another language were spoken. We also interviewed middle-class respondents of both Hispanic and Afro-American ancestry.

Most respondents spoke of opening the house when a cool breeze was present, including many who were not observed to do so in our nighttime window observations.

Ceiling fans are all but universal. Respondents without them said they intend to install some. The limit on the number of fans appears to be the number of rooms. Three fans are the norm, while five ceiling fans have been installed by a significant minority. A number have floor or pedestal fans in rooms without ceiling fans, as many as eight in total.

One person mentioned that a sharp contrast between inside and outside temperatures upsets one's biorhythms. Another sets the thermostat to 73 but only uses it when it's 'really hot'.

Equal numbers refer to noise and security when asked why they don't open windows at night for cooling.

The magnitude of the electric bill seems more related to the pattern of use than to the temperature setting. One family of six set the thermostat to 80 degrees but left it on 24/7, and were hit by a \$220 bill. Another family set theirs to 73 but only use it when it's 'really hot' had a bill of \$66.

When asked about their ideal temperature, a large majority referred to the reduction from their current thermostat setting, rather than to the resulting temperature. "I'd like it X degrees cooler." Perception is relative here, not absolute.

Two households with electric dryers were favorable to clotheslines, unlike most others. Among the higher income respondents, they regularly hang clothes on lawn furniture. All others asked said they have gas driers, and most were adverse to clotheslines. [I imagine the moderate-income adults, like myself, as having hung clothes on a line as a hated childhood chore.]

One respondent that works in the building trades said that "ignorance and environmentalists" are responsible for California's energy problem. He then went on to

describe a consumer energy cooperative as a favorite solution. Several others complain that building has continued to raise the demand for electricity, and should be curtailed until energy supply is planned.

As a general pattern, when one adult is at home more than the other, that person tends to control the AC. Where both work outside the home, whoever arrives first or leaves last controls it. Among the two-income families, either there is some form of conflict, or there has been some kind of agreement about what should be done. A large minority simply left control to whoever takes it, and if uncomfortable they simply change it themselves.

Those with pools tend to opt for higher thermostat settings. Some use the pool as personal evaporative cooling, and/or may have been hit by large energy bills and adjusted. Kids of families with pools may not touch the AC but are told to jump in the pool when hot. The one instance of an eight-year-old being allowed to turn on the AC occurs in a family with no pool. Several people without pools say they take a cold shower before choosing to turn the AC on or to a lower temp.

Adults whose work outside the home involves at least some time outdoors tend to have a considerably wider tolerance for temperatures at home. These folks tend to consider any common indoor temperature as pleasantly cool.

More people are aware of the role of the effect of the recent long-term power contracts than are aware of the effects of the deregulation of supply. The Governor, the power suppliers, and the legislature are most often mentioned as responsible.

Only one respondent volunteered that he occasionally forgets to turn the AC off or down during the day when no one is home. Likewise, only one respondent claims to use the programming functions of the thermostat during the summer, and even he turns it off manually when windows are opened at night.

More than a few claimed that leaving the thermostat at the same, or only slightly higher setting all day saves energy. Two make the case that the temperature of the building core, if allowed to heat up, takes more energy to cool down than if it were kept cool to begin with.

The most common response to media campaigns for conservation is that people will do their laundry at night, regardless of whether they have a gas or electric dryer. Also common is turning off appliances, particularly computers.

Having a breeze is more frequently cited as the signal to open windows than is the temperature differential between inside and outside. Extreme heat will cause most window-openers to keep theirs closed overnight, unless they stay up late enough to experience cooling outdoors. Very few window-openers will open them before going to bed in anticipation of cooling later at night – the cooling has to be sensible at the time the windows are opened.

Two two-story houses with families of three differ in that one has a two-zone system and the other a one-zone. The one-zone is operated at 77 degrees when people are home, and 81 or 82 otherwise. The two-zone is operated at 77 degrees downstairs when people are home, and 82 upstairs at all times, excepting very hot evenings when the setting is changed to 79 upstairs. The house with the one-zone has a typical summer electric bill from \$150 to \$200, while the two-zone has been from \$40 to \$60. Both houses have solar shade screens and multiple ceiling fans.

## Appendix E – Davis Interview Notes

This Appendix contains Bruce Hackett's notes recorded during interviews conducted in Davis. Names of those interviewed have been changed out of respect for their privacy.

### **Sam Shorham**

Soon-retired secondary school teacher, 62, told me a story that nicely establishes a diversity theme: he said he goes to a gym and often meets there with a colleague who is also a neighbor, in a similar house; recently, they talked about their AC-use (of course people talk about the weather a good deal, and this summer's "energy crunch" has given that a further boost) and found out that both of them turn the AC on at 5, both set it at 81, but Sam runs his for about a half hour, and the other chap keeps his on until 11 p.m.

The house is in west Davis, 35 years old, 4br, one story on a slab, south-facing; they've been there 30 years. He turns on the AC sometimes -- when it's above 100 in the afternoon-- in the early morning, 5:30-6, and can get the house down to 70 "on a good day." If he can't get it that low he'll turn on a box fan, put it in the doorway and "aim" it at the thermostat "so I fool myself." He really needs a more powerful box fan, he said. His "ideal" temperature is 68 which creates some minor tension because his wife likes it quite a bit warmer, at least 76-78 and ideally in the mid-80's, though she lets him do the thermostat settings.

They have three ceiling fans and one tall standing fan, and the use the c-fans a lot; they don't open the house at night (except for one small, high window) for security reasons. They think they are a good deal more conserving than their next-door neighbor (not the one noted above) whose AC they can hear --it goes on regularly at 10 a.m, even on "pretty cool" days. He "like[s] air conditioning but also like[s] to keep it off." But he also admitted that he likes his workplace office temperature, which is cooler than he keeps his house, and likes not being able to control it because he'd feel an obligation to keep it warmer --though sometimes it gets too cool there and he opens his office window.

His comfort range: 66-72 preferred, 64-82 "would be ok with a moderate fan speed." He said they replaced their old AC about four years ago and that he had to "fight" with the HVAC people to get the smaller unit he prefers.

They "probably" wouldn't alter their house temperature for guests, but he complained that sometimes the guests alter it themselves: both of their grown (30's) sons like to open the house when they visit, even if the temperature is 100 degrees, because they "demand fresh air." [They have a swimming pool, however, and when the older son arrives in the heat with his two children the door leading to the pool is open much of the time in any case.]

He thinks the current energy situation in California is quite serious, with deregulation the cause and "outrageous gouging and manipulation of the market. He thinks conservation could be a major contributor to a solution and and thinks all the power plant construction is probably a mistake because it undermines conservation.

They have and use a clothesline, approve of swamp coolers but don't have one, wish they could get PV but have a flat roof. He said they did do a number of things to reduce energy use --reduced the amount of cooking (he noted that he had changed from hot to cold cereal for breakfast) and reduced their use of the pool sweep.



### ***Elaine Shorham***

Wife of Sam, a junior college English prof, and really enjoys the heat: our interview was on one of the summer's cooler days (76 at 11a.m.) and she said that the cooling trend was, for her, "distressing." "110 is probably too hot," but her ideal range is about 90-102. If it gets below 75 (where her husband prefers it --she said he "tries to freeze the house") she starts to "put on sweaters and blankets," although she likes to hike and if hiking can take it down to about 65. "I couldn't live in the east." She said that "Sam complains in the summer, I complain in the winter," and that she prefers drinking water that's at room temperature. She goes to swim at a club at 6 a.m each morning and that on the day of the interview she had run the car heater on the way to the pool. She also noted that she loves it when her closed car has been sitting in the sun when she gets into it.

At her workplace the employees have no control over the temperature and she had asked the administration to assign her a particular classroom on the top floor that never got too cold --the building temperature is set at 68 in winter and 78 in the summer -- though she thought it "actually" set at 80 in the summer and that sometimes it gets too hot for the students in the classroom.

They don't change the temperature for guests and she doesn't mind the house being open a lot when the grandchildren are there, but she did note that the oldest son does cool the house down at night for sleeping and she "usually tolerates" this.

They use the clothesline but she said that they didn't dry the sheets there until the energy crisis; she also clarified the pool sweep situation: they previously had run it two hours a day, but now it's about 2 hours a week.

### ***Delia Derrick***

She and her husband are the first owners of a NW-facing home in south Davis that was built in '98 --2 stories, 3 BR, 1800 sf. They have 3 kids --16, 9 and 7 and at age 39 she has returned to college to get her degree in literature. Her habit is to turn on the AC when the temperature rises above 85 indoors, and she sets it at 81-2. She would ideally have it at 79 but keeps it at 81-2 "to save energy money." They run their 3 ceiling fans, turn off the AC and open windows in the evening. But she said that her husband goes to bed earlier than she and that when she goes to bed she closes all the windows, theirs and the kids, upstairs and down, "mainly for security." Her husband would prefer the windows open all night, and likes it cooler than she. She said that he "programs" the thermostat but that she "controls" it. She thinks of herself as having a high tolerance for heat and that her friends always prefer it much cooler (and she likes it much warmer in the winter, too). 78 degrees is, for her, cold. Her classrooms are usually too cold for her as well.

She made a few comments about the energy situation, though it is plainly not a very salient issue for her: she is a native of France, and cited that to explain her own feeling that it's "ridiculous not to have enough energy." [She did agree with me, however, that it was also jarring to find so many nuclear cooling towers in so many otherwise beautiful settings in France.]

She doesn't use a clothesline but thinks they are a good idea --"but not visible, not the way they are in Italy." She has never heard of swamp or evaporative cooler, but she is

“all for” PV. She and her husband have talked about possibly installing an attic fan, because it does get warm upstairs.

### **Tom Derrick**

He is a 38-year-old “data network analyst” currently working on voice-computer interface issues. They turn on the AC in mid-afternoon and usually let it run until about 7; he sets it at 82 (“but occasionally 78”), but really they operate it manually, waiting until it gets uncomfortable (“because we’re cheap”) and then sometimes overreact.

The main cooling activity, he thinks, is opening and closing the house. He opens it up when he gets up at 6 a.m.; wife closes it at 9 or 10, “lately even later.” His ideal temperature is 72. “She likes it hotter, and I immediately cave in. I don’t notice it as much as she.”

Compared to his neighbors he thinks that he’s “more conscious of saving money. I think they’d keep their houses cooler, or warmer.

The only thing he knows about his AC is that it’s a Rheem, but he “would prefer a different way to cool. I’m not an AC enthusiast. I think I’d prefer a whole house fan, with a filter, and some humidity. I watch the home improvement shows.”

His comfort range is 67 to 78, “with little clothing.” If they had guests to dinner they would probably set it to 74.

At work “they keep it cooler in the summer and warmer in the winter than I would. But it’s driven mainly by the need to maintain the proper temperatures for the computers. I work with a half dozen of them.”

He feels that the current energy situation “is a function of bureaucratic inaction and corporate greed. Regulation made it less profitable to build new plants, but the Republicans shouldn’t have deregulated. There was this huge profit-taking. We need to build plants responsibly, and get FERC to behave also. And conservation is important.”

They have used a clothesline (but not at present) and aren’t opposed. He’s really attracted to the evap coolers “because they’re so much more efficient than the AC,” and looked at them at Price Club, “but they really need to be integrated into the whole system, not some big honcho out there. He also likes the PV approach, and says that he wants to put a patio cover in the back yard and maybe put a PV system on that --“we’ll look into it in the next 5 years.” He has “thought about” shade screens and decided that a whole house fan “would probably not be that helpful.”

### **Marilyn Fitzsimmons**

A 68-year-old retired grade school teacher, recently deceased husband, in one-story, 3 BR, 1500 sf house built in 1974 in north Davis; she moved here 1.5 years ago from Virginia. Her “typical” pattern is to turn on the AC between 1 and 3 p.m. when the temperature outside reaches the mid-90’s and indoors about 82. She likes to get it to 80 and that is both her “actual” and her “ideal” temperature; if she has company coming she’ll get it down to 78 “but I like it a little bit hotter.” She opens the house around 9 p.m. (opens “anything with screens”) and turns on the whole house fan for an hour, says that she likes the sound of the fan and the moving air, “and I like it cooler to go to bed, don’t care so much about that if I’m up and moving around.”

She contrasted her approach to that of her late husband: “he wanted less AC and less whole-house fan; he would say ‘Wait until you’re uncomfortable’ but I prefer to

anticipate that. He was stoic. He didn't get as hot as I do. There was a lot of fine-tuning with him." She also noted that they have a programmable thermostat but she doesn't know how to use it; her husband did, "but even when he was alive we just set it where we wanted it at the time; in fact [we] like to set it."

She thought she wasn't a "typical" AC user; the movies and the stores are too cold, sometimes hurt her joints. "And in the summer I want it to be summer; I want to live in it. But I'm not Carl [her son, who still lives in Virginia] --he won't turn it on until he's just flattened, maybe 95 degrees and also high humidity."

She also thinks her AC might be undersized --on a very hot day, 107 or more, she can't get the house below 84. But she was still ok with that temperature, could tolerate it; "at 85 or above you have trouble with sleep." She said she had friends who keep their house at 72 and that that is simply too cold, although if the house temperature could be gotten down to 60 at 6 a.m. "that would be great. Even 55 would be fine but that's not real." When she was teaching, the school was kept at 72 degrees "and we'd beg them to turn it up to 75."

The current energy "mess" partly reflects the fact that there are "too many new millionaires; we've also had cheap energy for too long, and there are the usual political shenanigans." We have to face up to it "and make conservation a prime focus."

She thinks clotheslines are fine --she dries clothes on a rack and sometimes just uses a chair; has "nothing against" evap coolers and likes the fact that you can run them during the day, unlike the whole house fan, but they're noisy and she wouldn't switch to one because she wants to "keep the house resaleable." PV she knows nothing about. She is currently trying to figure out how to shade the main entrance to the house, which faces west --"and by 4 p.m. the door is so hot you can't touch it." She has gotten her electricity bill (for April) down to about \$50 "by turning a lot of stuff off" but she hasn't replaced any major appliances (she told me of one friend who had replaced her freezer, dryer and refrigerator all on the same day); other friends are paying \$170 to \$250 for electricity alone.

### ***Karen Leath***

The house in south Davis was built in 1996; two stories, 1750 sf, 3 BR, one thermostat; she, age 40, develops programs for pharmaceutical lobbyists in Sacramento, and her husband is a househusband. He sets the thermostat, in the upper 60's because "he gets hotter faster, and he just freezes me in the car." She said that they had made a major effort to reduce their energy consumption from the previous year; they purchased three fans and almost cut their consumption in half (the latest total utility bill was \$110).

They open the house when they get up in the morning and close it mid-morning (10 or 11); the house is opened in the evening but not overnight, the latter for security.

She emphasized that her husband really likes the house "refrigerated," but he has adjusted because of the cost; adjusted about 10- degrees, "so now there really isn't any real conflict. And we think about this a lot now. It's kind of fun, seeing how low you can get your bill."

Their consumption she guesses is probably about the same as their neighbors, but not her boss; "we're thrifty; he certainly isn't. But I do do the laundry whenever I want."

She thought the AC is "probably" ok but the temperature in the house is quite uneven and the kids' room upstairs gets hot.

She wasn't certain about her comfort "range" --probably mid 60's to mid 80's but she couldn't be sure "because the thermometer in the thermostat is inaccurate." [Meaning, I assume, that they operate their cooling devices manually.] If anticipating guests they cool the house down to the mid 70's.

At work the temperature is often too cold for her and she wears a jacket and wishes she could open her windows (but can't); the management doesn't consult with the employees on temperatures.

Her take on the current energy situation is that it's a problem but the reporting has inflated it; the energy companies took advantage of deregulation; there wasn't enough planning. But "less consumerism is good for all of us." When asked about clotheslines she thanked me for reminding her about something she thinks she should use. She wouldn't want an evap cooler and thinks PV is good but the expense too great. She likes the fact that stores have been dimming their lights. "But don't dim the lights in the parking lots!"

### ***Riley Leath***

Karen's househusband, age 42. He said that last summer the AC was on all the time, 24/7, getting the house close to 70; now the house is closed at roughly 10 a.m and the fans are used but the AC not turned on until late afternoon. He knows that he can bring the house temperature down one degree in about 15 minutes, and he changes the temperature one degree at a time. Two of the three fans are recent additions, "energy-crunch related." The house is opened in the evening and in the early morning but not overnight.

He said that his comfort zone is probably 68-74, but he wasn't certain what his "actual" setting was since he ("usually") controls the control and just sets it up or down. "I get too hot faster than most. But when it's ok to sweat I'm not so concerned." When guests are arriving he'll try to get it down to 70.

He thinks the "crunch" is no longer really serious (July 20), and he was attentive to ideas for conserving ("the stuff that comes with the PG&E bill") but had no idea about the origins of the problem or what to do about it. Clotheslines are unattractive but useful; about evaporative coolers, PV, or the R-value of the home's insulation he was uninformed.

### ***Paula Minor***

A 42-year-old attorney (worker's compensation cases) married to Byron Means (next interview); 5.5 year-old house, they are first residents, in south Davis --2 stories, 1800 sf, 3 BR.

She said she grew up without AC (home or car) in Ohio and Florida and now "hates" the AC --"don't want to spend money to freeze myself." When living in Michigan they did have a window unit, to help Byron sleep, but she was delighted to leave Michigan because of the cold. Byron's pattern is the one they follow in this house because he (an artist) does a lot (but not all) his work at home. They open the house in the evening and at night, but they keep the windows in the computer room downstairs closed "so that I can be warm." So they don't run the AC for most of the day, and not until the temperature gets into the 80's (her "ideal" temperature is 79-80). It stays fairly

comfortable downstairs but “we have real heat” upstairs. They have fans downstairs, but not up: “Byron loves fans, so I hesitate to put one upstairs!” She says she adjusts to his needs for coolth by adding clothing. “I interfere only if the AC is on and I’m freezing.” She said she had also noticed that he rarely went upstairs and thought this because of the cooler downstairs.

Compared to others she thinks “I like much more heat. Outside in the mid 90’s is fine. Many people I know run the AC all the time. Some feel that it saves money to make the house stay cool, at, say, 77 and not let it heat up.

If she is doing something sedentary, and with the fan on, she’s ok until about 86. She also doesn’t like heated air in the winter, so she starts adding clothing at about 75. She’s not sure she would like it at 60, but we talked briefly about the ACC project and she thought getting the house that cool would be fine if it meant avoiding the AC.

They don’t change the temperature for guests, though she does insist on closing the windows when her mother visits, to keep mom warm.

In her workplace the workers have no control over the temperature and can’t open the windows, and she had reason to be happy about the current energy “crunch” --before this year it was so cold in the office that she would occasionally take a break and go to her car, parked in the sun, “for a sauna. In fact this year we had a blackout and I thought it was wonderful!”

On the current energy situation: “Steve Peace and the Republicans are responsible for it. Deregulation doesn’t work because there’s no real market there. The real crisis may be past, though.”

They had lived previously in east Davis and had a clothesline there; she was “not inclined” to do the same here: “Privacy is important here.” She is also accepting but reserved about evap cooling --visually about the same as AC, noisy, but the AC here is not really quiet, either. She would love to have a PV array “before I retire.” She also talked about her conservation efforts in general --tries not to run things during peak hours, esp. if the AC is on; she also reads the Cal-ISO web page occasionally, and thinks the energy problem forces people to think communally. “All those billions. Amazing. Why would anyone vote Republican?”

### ***Byron Means***

Married to Paula Minor, Byron is 46, and they have one daughter, 6. He said that he knows how to program the thermostat but doesn’t, likes to work it manually. The house is south facing so they can get some breeze in the summer at dinnertime, and AC use varies depending on the breeze. He doesn’t use a fixed setting but nowadays the lowest setting is probably around 78. The upstairs may be 15 degrees hotter, but he thinks the downstairs is always ok; “It would be nice to have an exhaust fan.” The house is of course not zoned.

He noted that they have one ceiling fan and said he and Paula had “discussed” another in the bedroom. They do sleep with a box fan running --they like both the sound and the breeze. They slept with the bedroom window open in the winter. And neither one of them likes AC. “I wish we had better cross-ventilation. We keep the windows open at night and my theory is that this is why we can avoid the AC most of the day.” He had noted that most of his neighbors don’t open the house, at least not wide open, at night, and that “this might be a safety thing.”

He thought that Paula had adapted by now to the cooler situation he prefers. They did have conflicts, a little “thermostat warring” because he likes it cooler. He said he tried to keep the house down in the 50’s in the winter “and then we did have war.” It helps to keep the temperature lower if there’s physical activity, although he thought that the gym he goes to is too warm, “but I’m there to sweat.”

He agreed with Paula that mother-in-law visits are probably the only time they would adjust the temperature for guests.

He has a studio in a large commercial building in Davis where he does some of his work; “I don’t control the temperature and it’s awful --too hot in the summer and too cold in winter. The summer is the worst, the studio is upstairs.”

The energy situation is basically political, in his view --Wilson et.al “--big gains by a few and lots of hurt.” What’s important is to get new sources of energy. He said that when Paula was in law school they had a clothesline but that the yard was too small here. He liked the smell of the clothes, tho not the stiff towels. He mentioned that the CC&R’s there were not good, but he thought they were largely ignored. [Prohibit clotheslines?] He said he didn’t know how evap coolers worked, and wondered about their practicality “because there’s so little water in the air.” PV he thinks is “cool” but too costly --should be built into the house so it can be paid for in the mortgage. He thought that the insulation in the house was probably ok but not great; but that they had a west-facing wall in their bedroom and the wall gets too hot, should be better insulated.

They did unexpectedly qualify for 20/20 one month this summer, although he thought that all they’d really done was to be “a bit stingier” with the AC.

### ***Tyee Carlson***

A 30-year-old kindergarten teacher; she and her husband have been in this south Davis house just 10 days --2 stories, 5 years old, 1700 sf, 3 BR. She wasn’t even certain that they have an AC because they haven’t use it yet. Moved here from a second-story apartment with west-facing glass in Martinez, where during the day the indoor temperature might get to 89; they would set the AC to 78 --had started out at 80 but felt that not adequate. They had a programmable thermostat in Martinez but never programmed it.

They have two ceiling fans and open the house after sundown, put on light clothes, frequently get an evening breeze. She said she also keeps a hair-spray bottle with water in it handy and “mists” herself with it.

Husband and wife differ in their temperature preferences in the winter --she likes it warmer-- but not in the summer. There are summer differences with her parents, however; “Dad would never turn on an air conditioner.” When her father arrives to visit in the summer “we have a real dilemma.” They usually use more AC if guests arrive because she thinks her comfort temperature is too high for most. Her range of tolerable temperatures is 60 to 85, “but real comfort for me is about 80.” In the morning 60 would be ok --“I’d just bundle up”-- but she wouldn’t want it to get colder than that.

The indoor climate is fine where she works, and the staff is consulted about thermostat settings.

She hadn’t been paying much attention to the current energy situation. “I assume it’s bad, and it would probably be better to assume it’s worse,” and she had no idea what to do about it, but she added that they did conserve in several ways, e.g. not using major

appliances during peak hours, not using the dishwasher, using candles at night (oil lamps in Martinez) and turning off electricity at the surge protectors. She said that their clocks were rarely showing the correct time but that she doesn't care; they had gotten used to the power going out regularly in Martinez.

### ***Cleo Renoir***

A two-story, 6 year old south Davis house in which she and husband had lived for three years; not sure of square footage but it's probably 1600-1800 if neighboring houses are an indicator; she is an equine veterinarian from France studying ultrasound techniques at UCD, and her husband is in "medical marketing." They have two brand new identical twins and her parents had come from Burgandy to help; this presented a somewhat comic situation because when I arrived for the interview Cleo and her father were running an errand and her mother, who spoke not a word of English, answered the door; I can speak some French but was so taken aback that I couldn't remember "oui," let alone "bonjour," but fortunately she was on the cordless phone with Cleo's bilingual brother and she just handed me the phone.

They have one thermostat and use the AC, set at 78, from about noon to 7, sometimes all night. There is a very large west-facing window and they keep the blinds on that closed, and run their ceiling fan. They open their windows at night, although two of the windows are sometimes kept closed "because of the nightingale" [mockingbird -- the nightingale is the European equivalent]. They also open the windows in the a.m. and keep them open until the AC comes on. And they wear light clothing.

Cleo likes it warmer than her husband, and she controls the temperature. They keep it at 70 in the winter. She said that her husband would like it cooler in the living room "but then it would be too cool in the bedrooms. [?] She said they envied the neighbors whose living room faced East "because they don't have to run their AC at dinnertime."

Her father, who speaks some English, asked why houses here don't have shutters, as they typically do on the continent, because shutters are much better than blinds; he also noted that his home has very thick walls, hence no need for air conditioning.

The AC is fine but too noisy, making it hard to sleep. Her parents are "ok" with it, but her husband's parents complain about the "blast" of cold air at night.

Their comfort range is between 70 and 80; when she was working upstairs she would keep it at 75, but now she keeps it at 78 because she isn't working there and also because of the new babies and to save energy. [!]

She is preoccupied with her new babies and had very little to offer on the current energy situation. They do have a clothesline and use it ("the rule in France") and she mentioned that she thought the Portage Bay apartment they had lived in for awhile "with tanks of water that absorb the heat --a great system." After the interview her father said to me "There is so much sun here --why is there so little solar energy?"

### ***Miguel and Pina Ricardo***

They are the first owners of a two-story, 4 BR, 2300 sf south Davis home completed in '98; he is the Assoc Director for Research for a large seed company in Woodland, and she is mom --he 43, she 41. They have two young children and one 15.5.

The house is not zoned, though they wish it were. They try not to use the AC much -- both of them grew up in a small Mexican village without it, in a climate similar to this one. Usually they avoid it until the outside temperature is over 100, but she does occasionally turn it on at 5, set at 72, when he is coming home because he likes it somewhat cooler than she. They will run it 2-3 hours then.

They have 2 ceiling fans --living room, master bedroom-- and one “mobile” box fan; they run the fans during the day “sometimes, and keep the blinds closed. They open the windows at 7 or 8 depending on the temperature, and open only the upstairs windows (security).

She likes it warmer than he; in the winter she likes more furnace heat and he prefers to simply add clothing. He says that he doesn’t like air conditioning “whether it’s heat or cool.” Sometimes the kids set the thermostat --no one person controls this. But because the house is big there is a difference between the actual and their ideal temperatures --“we have it about 10 degrees less cool.” And they do have a heat problem --the house has a skylight “that makes it like a greenhouse upstairs,” and the kids complain, especially the teenager. “We try to cover the sources of heat --put cardboard in the windows, which doesn’t look nice.” They also don’t think of themselves as “average,” and try not to stray too far from the ambient temperature. “We want our kids to adjust to different condition. In the states people make it too hot or too cold, and then you get allergies.” Pina also said that she gets headaches in air conditioned building or cars.

They don’t know the brand, size or efficiency of the AC but think it adequate.

Their comfort ranges: she from 96 (maybe even 98) to 70; he doesn’t mind the cold, even down to 50, but doesn’t like it over 80. They have a king-size bed, which facilitates the fact that he sometimes uses no covers and she likes two or three.

Do they lower the temperature in the summer when guests are coming? “If they’re Americans, yes, to 72. Mexicans no.”

At his workplace Manuel says that he is usually unhappy with the temperature -- they keep it too cold. He says he complains, especially now with the energy crisis. In the winter it’s too warm. He said that when he complained they did change the setting but then he thinks that others complained, so he just covered the AC and heat duct openings in his office.

They think the energy situation is serious, and everyone’s problem. “There is so much waste --far too much light, far too cold in the supermarkets, and people need that because they grow up that way. Not in Mexico. Here the neighbors lights are always on, but we turn ours off when not needed.” Manuel says “If I can see, no lights. The lights are always on at the office.”

They have a clothesline and use it --in the side yard where “it isn’t very visible.” The clothes dryer is used only in the winter. “We grew up that way in Mexico and besides, the dryer shrinks things. We also have a dishwasher and don’t use that either.” They wouldn’t use a swamp cooler, and they think that PVs are “interesting.” They have seen the ads regarding conservation and changed their light bulbs --not CFs but “more efficient” bulbs. Their utility bill has been around \$80 --tho it went up to \$120 once. Manuel said that he takes cold showers, which save energy “and make you stronger.” Pina said such showers would make her sick.



They also told me of a friend who leaves her AC on all day and says that she does this to save money.

### **Wally Fontinelo**

This is a two story, 1730 sf, 3 BR and 3 bath house built in '95 that he and his wife have been in since '97. He is 36, a sales manager for a computer; she is in school getting a degree in early childhood education. They use the programmable thermostat manually, guided by the "feel" of the house; usually it would be turned on when the temperature is about 80, or 82. It would be nice to have two thermostats and a zoned home because it gets hot upstairs, probably 10 degrees hotter than down. He also said he thought the vaulted ceiling downstairs made the upstairs seem "squeezed --you can touch the ceiling fan with your hand" and that made it feel even hotter.

There are three ceiling fans, one in the living room and one in each of the two bedrooms upstairs; he'd like to add one to the downstairs bedroom. They open the two northeast bedroom and two hall windows upstairs, and keep the bedroom doors open so they get some breeze; they could open the bathroom window but like to keep out the street noises. They keep the downstairs windows open during the day "and it gets a little warm, but we grew up in the Phillipines."

He said that his wife had a wider range of temperature tolerances than he, both hot and cold. In the winter they do program the thermostat and she puts in the numbers; they have preference differences, but accommodate each other. They don't indulge their "ideal" settings --would prefer it 72 in the winter and set it at 68; in the summer they just "feel" it but keep it a little on the warm side. Their "ok" range would probably be from about 60 to 82. He thinks their friends keep it cooler; when they have a party they set it down to 78, "maybe 76." Doesn't know the brand, size of the AC.

He says that in his work situation it is always cold --probably 68 or even lower. It is especially cold in the morning --"you have to wear two shirts, and ski caps in the winter. We complain about it but nothing happens. And there's alot of fan wind --we have to hold down our papers at night."

He attributes the current energy situation to "lack of foresight about deregulation. Of course there'll be gouging, and we have to live with it. It did effect our energy use, made us conserve somewhat, keep it a little warmer."

A closeline would be "doable. We don't have one outside, but we do dry a lot of clothes in the bedroom." They would be "open" to PV "but it's a big investment." They also bought "heavy" curtains to help with energy. They have noticed the conservation ads; "we vacuum in the evening, wash clothes then, moved energy use away from the peak. Actually we mostly were doing these things in the evening, but now we're conscientious about it."

### **Merline Daniels**

South Davis house, completed in 3/99, 1950 sf, 3 BR; she and her husband, both 40, are the original owners; she is a dental assistant, and they have two daughters, 6 and 15 months. The house is closed during the day and the AC turned on at 5:30, set to 78-79. The upstairs [as with most these houses, clearly] is warm and "stuffy." They have and use ceiling fans in the living room and the downstairs bedroom. They open some of

the windows at night --a downstairs front window, the upstairs balcony window and the girls bedroom.

She says that her husband is “easier with it hot. I’m moving a lot and need to keep it cooler. He’s just not that concerned.” She controls the thermostat setting and there’s no conflict over this. They try to keep it just a little bit warmer than her ideal -- 77.

Not sure how she compares with the neighbors; at least one neighbor conserves much more than they do, but mostly she thought they would probably be average.

She wonders about the adequacy of the AC --sometimes it seems too small. “I hope it isn’t.”

Her comfort zone is from 76 to 80, approximately; when guests come she sets it to “I think, about 76.” When she’s at work it’s cooler “and it has to be because of the lab coats; they set it at 74 and the AC runs all the time. All the women patients say it’s too cold.”

Her one thought about the energy situation was that we shouldn’t rely so much on one source of power. Wouldn’t use a clothesline --“I don’t like my clothes on a line;” a swamp cooler “might be ok; PV? “Ask Bruce” (her husband). Whole house fans “are good, but might not work here.” She said she didn’t know whether their insulation was good, but they did pay attention to the energy conservation campaign: “We paid attention, do our laundry and dishwashing in the evening or the early a.m.” Their last utility bill was \$120.

### ***Bruce Daniels***

He is an “economic development” management consultant, and says that they take two newspapers and don’t read either one.

His wife controls the AC --they turn it on at the end of the work day and run it manually. “I wouldn’t use the AC at all --not because I’m frugal but because I’m comfortable with it warmer.” Their three ceiling fans are on most of the time, and they open the house at night; they keep the downstairs windows closed for security except for the downstairs master bedroom.

Although Merline would like it a bit cooler “there isn’t any tension over this. We keep the house around 82, without programming the thermostat; the ideal would be a little cooler, about 80,” He thought they were “probably typical.”

Doesn’t know about the AC but thinks “we’re underpowered.”

Their ideal temperature range would be 75-85, but they could tolerate 75-95. If they have guests they turn on the AC, but still set it to 82. At work it has to be a little cooler because he has to wear a shirt and tie (though he does a good deal of his work at home, where he wears shorts). He accepts it hotter in summer and cooler in winter than his workmates.

He thinks the current energy situation is very serious, “potent,” because of its potential impact on business. The approval process for power plants “bows too much to local opposition.” In his view “the state gives too much attention to conservation --for example, asking auto dealerships to turn off their lights.” They didn’t try to participate in the 20/20 program or monitor their energy use; he wouldn’t want a clothesline or swamp cooler; “PV shingles would be good as an investment. He’s thought about a whole house fan but not shade screens [which they could surely use on the west-facing

front window; our interview was at 5 p.m.]; doesn't know about their insulation but wonders whether it's adequate.

### ***Mona Black***

Retired UCD staff member, 69 years old, who works (at home) part-time as a bookkeeper for various environmental groups; the south Davis house was built in '97: two stories, 1800 sf, 3 BR, one thermostat, and she was the first owner. She needs the AC only when the temperature outside reaches the high 90's; she leaves it set at 74 and it goes on when the indoor temp is 75-6. The AC is off at night and she opens all the windows except those in the dining room (too hard to open) and the living room (inaccessible). Last night the temperature got down to 62, so the AC went on at 4 and off at 6. She said that the upstairs temp is about 2 degrees warmer than downstairs, but that's ok. She has one ceiling fan in the living room and turns it on at 6 a.m. when she gets up, keeps it on through the morning. There is a big standing fan on the second story but she doesn't use it.

There is an ideal/actual difference: she would prefer a temperature of 68 but keeps it at 74. Her "comfort zone" is 62-74; 58-80 is the "tolerable" spread. Many of the people she has talked to about it (say they) keep their settings higher, which she interprets as a response to the price of electricity. She lived many years in another house in Davis without AC, where cold showers --hot in winter-- were important, and she thinks air conditioning is "magical."

She changes the temperature in the house for guests but only in the winter, when she raises it a little because friends are uncomfortable at 68; she turns on the gas fireplace.

She had a number of thoughts on the current energy situation in California. Wilson used the neophytes in the legislature to get deregulation through; FERC people are (expletive), easily manipulated by Cheney. Davis made some serious errors on long-range contracts and on upgrading production but she doesn't blame him "a lot." PG&E "screwed us by storing their assets so that the high-rollers wouldn't lose; the bankruptcy is corporate stuff."

Of clotheslines: "sure but you're not supposed to use them here; I dry my clothes on a rack in the garage and use the dryer for sheets and towels." She wouldn't have a swamp cooler but PV "absolutely. If I had the money I'd do that. I watch that." She said she didn't need a whole house fan "because I already have the breezes;" and she doesn't need solar screens because she doesn't get bad sun. She's not sure about her insulation --whatever is required in Davis-- but thinks it's R-30 in the attic.

She said she was "pissed at [Gov.] Davis because I've always been a conservationist and he assumes that no one is. Very condescending."

Her latest energy bill was about \$50, of which \$3.50 was for gas.

### ***Abby Bend***

There is a 2-story, 2.5 bath, 3 BR, 1860 sf south Davis home built in '99 and she is the first owner. She is 46, with an 18-year-old son who lives in San Francisco with his father and a 10-year-old daughter who lives with her. She works in Sacramento as a health program advocate paid with tobacco money.

She keeps her AC set at 82 during the day when she's at work; when she comes home, if the outdoor temp is over 102 she'll turn it to 73 for two hours and then turn it off, although "a few" times she has left it on all night, especially when her son visits because he's not used to the heat. She has two ceiling fans, in the living room and her bedroom, and she'd like to add two more. "I love the sound of the ceiling fan." She opens the house at night but not downstairs (security). There is a skylight in her bedroom upstairs and it gets hot there --"I have to do something about that;" one night she tried to sleep on the kitchen floor but was attacked by ants.

Her daughter is "ok with the heat" and there aren't any conflicts over temperature. She has a programmable thermostat but she doesn't program it. There are also no differences between her ideal and her actual temperature settings, though she keeps it a little cooler than perfect in the winter. She thought her approach was "atypical, because I'm not a whiner. I'm more adaptable than most; I dress up, or down, depending on the weather."

She says the AC is good, but doesn't know its size.

Her "comfort zone" is 73-76 and 73 is about the lowest she'll tolerate although she can accept it up to 81. If guests are to arrive she'll put it at 74. In her work setting the temperature are "ok --too cold in the winter and too hot or too cold in the summer; If I complain they'll change it, but I don't."

The current energy situation is "very serious. Financially. For everyone. It started with Wilson and deregulation, but it's complicated; Davis was short-sighted, and now Lundgren is happy.

Clotheslines? No, "I have a nice gas dryer." Swamp cooler? "No, I had one in Sacramento; too noisy." No knowledge of PV, or of her insulation levels. She also said she thought a lot of conservation is "symbolic --you make a statement when you have 'em but don't use 'em." But she thought that she must be doing some conserving because her energy bill is smaller this year than last --that she "might" have qualified for 20/20, and she concluded with "I have to get more serious about this."

### ***Kit Diamond***

3550 sf house in the "castle" neighborhood of north El Macero, built 4/99, first owners; 5 BR, two stories, zoned, SmartVent equipped; she, 40, and her husband, 49, are both in pharmaceutical sales. Two kids. When I told her that my house was less than half the size of hers she she gasped and said "I'd love to live in a house that size. This is just too big."

She said that they "hardly" use the AC; they turn it on between 8 and 10 when it's 90 upstairs, or downstairs when it's 105 outside and 85 in, and they "read the thermometer all the time." They have 7 ceiling fans; they open the house at night "sometimes," but the kitchen door (there is a swimming pool, with kids going in and out) is open all day. At 9 pm they turn on the SVent and it runs all night long. "Sometimes we turn it on in advance because we know it will get cool. Sometimes we forget to turn on the ceiling fans; it gets to be 91 upstairs. In the worst case we're running the whole house fan [her name for SVent], the ceiling fans and the AC to get the kids to sleep. After that we open a few windows, but the kids have allergies and we worry about asthma so we mainly keep it closed. The [SV] has an allergy filter; we're supposed to wash it every month but we do it every 3-4. The allergy filter is fabulous."

Her husband is “fine” with the heat; “he grew up near Hemet and feels better with the heat; he does require it down to 83 when he sleeps but I’m cheap, I would draw the line at 84-85, to be frugal. My mother is very frugal, very tight. And I don’t like to be wasteful; there’s too much waste. Ideally I’d like to have it down to 78, but I tolerate the higher temperature because of the cost. Last year’s bill was \$180-280, the last one this year was \$140, so we qualified for 20/20. But the winter bill was \$400 so we put on jackets. (They work at home, in the “den.”) We got electric blankets and kept the house at 62-65.” She said the patio created a lot of heat and they wanted to get a patio cover, perhaps plant a tree to shade the south side of the house.

She thinks they have a higher tolerance for both heat and cold than their friends or neighbors. “And we like to see how low we can get the bill.” I suggested that sometimes it feels like a game and she liked that --“Yes, that’s it, a game.”

She thinks the current energy situation is “very serious,” that there “wasn’t careful planning for the huge population explosion, not enough thinking ahead” but that “ultimately we’ll have new plants.”

Clotheslines “are unattractive; I don’t like the looks, but we have a line for the towels he kids use when swimming.” Evap coolers “are fine, but too noisy; I like it quiet.” She is “open” to PV, “but it has to be designed well, built into the house.”

They did do some conserving this year: put “Tintworks” on their windows (“73 percent sun reduction, easier on the eyes”), unscrewed 5 of the 10 floodlights in the kitchen. They got “some” energy-saver lights, and unplugged a freezer, “and we wanted to be educated on this.”

### ***Richard Wilson***

This is the same model house as Mona Black’s (above), and he has been there, a single man, since August of 98, when the house was completed. He is 49, a “computing resource manager.”

He said his use of the AC “varies a lot, depending on what I have to do the next day. If I have a meeting I’ll use it to cool down, and my schedule varies a lot. I don’t use the timer, just turn it on or off. If I know it’s going to be hot, over 100, I’ll turn it on, set it to 85, go to work. I don’t say ‘I want it to be 78 at 6 p.m.’” It gets warmer upstairs -- “probably 8 degrees --the problem with a two-story house. This is a general problem with California houses --too cold in the winter, too, with their high ducts.” He has two ceiling fans “and they run most of the time.” He opens the house at night --all the upstairs windows, especially on the south side, for the delta breeze, “and I need a ladder so I can get up to the north windows to install screens so I can open them.” He had his windows upgraded to double-paned vinyl, and he has “honeycomb” blinds (Hunter-Douglas) on the windows --“top down, bottom up”-- and foil-covered blinds in his bedroom.

He wasn’t sure if there was an ideal/actual difference. “I might turn it down to 72, but maybe not. I don’t like the abrupt transition. In the car, going to work, I don’t turn on the AC, though I might use it some on a long trip. A friend and I both keep the car windows open when driving in town.” He said he had an aversion to AC because he has allergies and it dries everything out. He also noted, interestingly, that one “can’t be casual about it if you have an aversion to air conditioning; it has to be medical or moral, strong feelings.”

He said his friends were conservation-oriented “so I’m average there in energy use; but with the windows open I can hear the AC’s running. But there are babies.”

He knows his AC is a Rheem but doesn’t know the size, although he thinks it’s not very efficient. He said that when he lived in Sac his pay for AC was about \$100; when he moved to Davis he ‘treated’ himself to AC and got a \$500 bill for the first month. “Terrified.” But he found out that it was the builder, during the last month of construction.

An ideal/actual difference? “The summer is different than the winter; it doesn’t matter how cold it gets because you know it will get hot; my upper preference would be 85 so I could tolerate the mid-90’s. There’s really a vast no-man’s land between comfort and discomfort. It depends on the use of fans, too.”

When guests arrive: “A friend who doesn’t like heat will set it to 78, or 76 at the lowest.”

In his work setting he shares an office and the office contains the servers for his computer networks, with their own AC. It’s on the west side of the building. “I have control and keep it at 76 in the afternoon. My office mate likes it warmer than I but he works at night; he turns the AC up, or off.”

He said that “in one sense there’s no energy crisis, just a conspiracy of power producers and sloppy, poor planning. It’s hard to believe that the delivery system is archaic. The greed has been so great that it at least focuses attention. I don’t know what to think of municipal utilities; SMUD seems good. I don’t know how it will end. People don’t know that they don’t pay the full cost of energy.

Clotheslines? “I’d love one and will integrate one when I do my garden. I was raised in upstate New York.” Evap coolers are good too --“I have a rural perspective. Solar hot water is good too; there’s no aesthetic problem. And PV: “I’d like it. I don’t know if I’d qualify for the Davis/SMUD program; it’s pricey.” And he said: “I was surprised that there wasn’t more difference to Davis houses. I’d like a place in the country.”

He said he hadn’t conserved more lately because he already leads a conserving lifestyle. “The 20/20 program? I heard it called a reward for energy hogs.”

### **Katey Mong**

The house was completed in 98; two stories, 3 bedrooms; not zoned. She and her husband are both family doctors, he 36, she 33. There are two kids.

They operate the AC manually, set it on a timer, at 88; she says it is “usually off. But yesterday I set it to 86, when it was 104 outside.” They have 3 ceiling fans and plan to get a 4th to use in the bedroom that they use as an office. She said it was very hot upstairs and the kids couldn’t wear night clothes, but they added shutters to the windows and that helped. They open the house at night, “at probably 5 or 6 p.m.” (She said her neighbors open their garage door and rear door in the evening to get some breeze, then close the doors when they go to bed, for security.) They open their house at night upstairs and there’s some difference with her husband on this matter: “I like the windows open all night; he likes them closed at night. Right now it’s energy conservation, so we agree. I would keep it cooler. But last year, even before the energy crisis, we didn’t use the AC. Our friends were amazed. But I don’t like air conditioning --it feels like fake air to me, and I really am comfortable without it. I don’t think we’re typical --really off the curve-- but honestly not uncomfortable. The real key to our comfort is the fans.”

She has no knowledge of the AC brand or size, nor of insulation levels.

She said that her “comfort zone” is from 60 to 90. If they have guests they would turn on the AC and set it to 78, “and some people have complained.”

She has been working for the past two months in Sacramento in a setting that’s “too cold --I have to wear a sweater under my white coat. And we can’t touch it; it’s freezing. Post-menopausal women like it.”

The current energy situation “is serious, and California doesn’t conserve like its reputation suggests. Cold offices, computers on all night, all the lights on. Education is important. And we need alternative energy --solar, for example.

She has and uses a clothesline; doesn’t know about swamp coolers (“They’re big in Merced but I don’t know how they work.”) PV “is good, but we couldn’t afford it now.” They have responded to the energy situation by adding shutters, not using the dryer, and changing all the light bulbs. “The only bad thing here is the stand-up freezer.”

### ***Skip Mong***

He said that this house faces northwest and gets warm upstairs; when they lived in Atwater they would have the AC at 78-80, and set it up at night. Here they open the house in the evening, upstairs and down, then close the downstairs for security reasons when they go to bed. “We both lay off the air conditioning. She [Katey] tends to run a little hotter, so she likes it a little cooler --more often than the opposite. She makes more adjustments; she breaks down and turns on the AC sooner than I would.” There is an ideal/actual gap --“I grew up in Cupertino, and if cost wasn’t a concern I’d keep it cooler. I don’t think we’re typical --we keep it warmer in the summer, cooler in the winter. I’m frugal in general --grew up in a conserving family and it makes me feel better to conserve energy. I’d say it’s about 50/50 money and conserving. I get a kick out of being more efficient.” He said his optimal comfort range is 70-76; his allowable range is 64-85. “Fans are very important.” If guests are arriving he would “probably bring the house down to the comfortable range” but he added: “when you set the temperature you don’t know what the house temperature actually, really is.”

In his workplace the temperature is very cool, in the low 70’s, and those who work there have no influence over that.

In his view the energy problem today is a problem of energy usage in general, and the need for conservation.

He’s “all for” clotheslines, and they have one. They had a “mini” swamp cooler in Cupertino and it worked fine; “you can’t compare it to the AC, but it’s more efficient.” And he is also “all for” alternative forms of energy,” such as PV. At their previous residence they had a whole house fan and he thought it too noisy. Regarding the current conservation campaign in California “we don’t watch TV much; I heard about the 20/20 program but don’t know if it applies to us.” He didn’t know about their electricity cost; “Katey pays the bills.”

### ***Halley Grain***

This is a 3450sf home in the Warmington section of north El Macero, and it has a SmartVent. Two stories, 4 BR, they have been in it one year (the first owners); the kids are 7, 4 and 4 (twins). She is a hairdresser, 43, and her husband, 39, is a management consultant on marketing and organizational issues. She was interviewed at her work site

and he later came to the Sociology dept to be interviewed; both thought the kids (with nanny) would be too disruptive. The house is zoned, with one AC.

She said that they simply set the AC at 78 and leave it there “or if we’re very active I’ll set it down to 77.” The SmartVent she said she turned on when she went to bed and set it at 74, but then she said she was “trying to recall the instructions --74, is that outside or inside? Maybe I’m using it wrong.”

They have two ceiling fans, both in bedrooms, not in the family room because “the kids [would?] complain;” she also said that they didn’t open the house at night both for security and because “the kids don’t like the outside noise.” They use the ceiling fans “in the in-between season.”

She said that her husband tolerates both heat and cold better than she. She controls the temperature, however, and “there’s no real conflict.” She said, as an aside, that the AC broke down on the 4th of July, when it was hot, and it got to be 90 in the house “but we didn’t notice it.” In the winter “we can’t get warm but we won’t turn it above 68.” Comparing herself to others, she thought that others she knows (neighbors) “stay hotter in the summer and in the winter, both.” Her “comfort zone” is 76 (though she referred to this as “freezing”) to 80, though when she gets up it’s usually 74 and 71 is ok. If guests are arriving she won’t change the temperature setting “but sometimes turn on the fan if it’s stuffy.”

Their AC is a York, 5-ton, “and probably not efficient.” At her workplace the AC she said was “old and bad; we have to run it all the time because of the fumes but by 4 p.m. it’s still 85 and I have to work until 7. We really need it cooler at work.”

Regarding the current energy situation she said she knew very little; “we always try to conserve but don’t want to be uncomfortable.” About clotheslines: “they’re ok. We have one but I don’t use it. Lazy. It would be o.k, if a neighbor did, though.” Swamp coolers? “They don’t bother me, and they’re good for your skin. We had one when I was growing up in the mojave. They’re noisy but our AC is very noisy and the SmartVent is noisy too.” They would “put in PV if we could afford it.”

As conservation measures “we did put in many shutters on the south side -- wonderful hardwood shutters-- and we want to add awnings.”

On the current energy situation she said “we did try to conserve but it didn’t work and we got angry. The bill was over \$400 in January and \$380 this last time [July]. We have to run 3 pumps for the pool, and we do 7-8 laundry loads a week, and the dishwasher...”

### ***Martin Grain***

He said that his kids’ ages were 8,5 and 5 (see above), and that he liked to emphasize the “leadership training” aspect of his management consulting work.

They keep the house at 78 or 80 in the summer and 68 in the winter, automatically. He said they turn on the SmartVent at night, “or sometimes turn it on. We have had situations where we fail to turn on the AC and have left the vent on so when the house gets hot in the afternoon the vent goes on.” They have two ceiling fans and they use them mainly at night. “Twenty-five percent of the year we open the house; there’s no set pattern. Not even a cool summer evening. We keep the house closed, close it at bedtime, for security reasons. My wife is especially paranoid. I’m more apt to open windows, and leave them open at night, than she. But I defer to her. It’s her domain, the



house. The same is true with the AC. We have programmable thermostats but we don't program them. [He gets reflective.] Come to think of it, that would deal with the SmartVent issue."

He thinks their energy consumption is "average." He doesn't know the brand of the size of the AC but is "happy with it." His temperature "tolerance range" is 55 to 88; the preferred range is 78 to 81-2. He recalled that in 1987 they had lived in an uninsulated mobile home in Lancaster [high desert] and had a swamp cooler that "kept the house tolerable, got it down to 90 degrees."

They don't change the temperature for guests.

The comfort when at work "varies. I work at home often and it gets to be 85-6 between 3 and 6. I don't cool it because I don't want to cool the whole house. When I'm teaching management classes I keep the temperature colder, 75 or 73 --it keeps the students awake."

He thinks the current energy situation "is a political scandal. The monopoly of large organizations. Deregulation would mean more companies coming in, but they found it hard to do business in California. And there's NIMBY in California. The power companies misjudged it, though. Arrogant. Bought the Governor.

He wouldn't have a clothesline or a swamp cooler "in this house." PV he finds appealing. They have done a little conserving --added the shutters, bumped up the temperature some, turned off the computer, turn off some of the lights the kids leave on.

### ***Jenean Mathias***

The house is in the Warmington subdivision, n. El Macero; 2 stories, 5 BR, "32 to 3500 square feet," zoned, equipped with a SmartVent; her husband, 65, owns a lazerwelding firm in Fremont and commutes there daily by train; she is a retired public school administrator. The house is 2.5 years old and they are its first owners.

The downstairs thermostat turns the AC on at 80 and 78 "at night;" upstairs gets the AC at 78 and 75 at night. Her husband has to be on the train at 5:30, and when he leaves the house she opens it up, then closes it up "at 10 or so; it depends on the warmth of the day." They have a ceiling fan in the "Great Room" and one upstairs in the master bedroom, one purchased but not yet installed in the library, and they plan to get another for one of the other bedrooms. The SmartVent "we set to the manufacturer's recommendation; it comes on in the evening and cools the attic and upstairs; the vent does a good job --the vent and the air conditioner are both fine, and with a pool and a hot tub the monthly bill is about \$265 total. Also the bamboo curtains really help a lot" [there is a lot of west-facing glass and the curtains are attached to the trellis outside and shade much of it but not all].

She says that she and her husband have roughly the same comfort requirements; she likes the windows open more than he --"better for allergies," and she controls the settings because she's at the house. There is a difference between her ideal and her actual temperature settings: "I would set it at 76 to 78; now it's 80; above 80 it starts to get stuffy." [Later in the interview she noted that they are both "collectors" --the walls are covered with framed Thomas Kincaid prints, one bedroom is filled with dolls, another with stuffed cats; her husband collects small "fairy lamps" and they have a large spoon collection; all the "stuff" in the house, she said, "exaggerates the stuffiness of the house when it gets over 80."]

She guessed that their energy-using behavior was “probably typical of retired folk.” she doesn’t know about the neighbors, most of whom are not there during the day, but she said that her daughter, with three kids, relies on ceiling fans and doesn’t use the AC during the day because the doors are being opened and closed all the time.

Her comfort range: “the top would be 85; I can tolerate that, but I’m happy at 80. I don’t like to get it below 76, but sometimes in the early morning it will get down to the low 60’s and I put on my sweatclothes.” When they have guests --e.g. summer pool parties-- they “turn the downstairs thermostat off and set the upstairs to 78. If people are coming to dinner we leave it at our usual setting.” She also said that they do sometimes program the AC to be off for a selected period of time --she goes to the bay area on Mondays, for example; she also emphasized that weekends and some weekdays are “different.”

She thinks the current energy problems are serious --a big impact on kids, with no AC in the classrooms, and on the economy; she said her husband’s energy bill at work is about \$40K a month and has tripled from last year, and that with 15 lazers and 30 milling machines he loses several thousand dollars during any 30-minute blackout.

She “loves” clotheslines, “but we can’t have them here; we do air blankets on lines that others can’t see.” Of swamp coolers and PV she has no knowledge, and she noted that while they did some conserving “we did add a pool and hot tub this year.”

### **Cass Shriver**

They have been in the south Davis house 5 years, the first owners; 1700 sf, 3 BR, 2 stories, not zoned. Her husband, 37, is a mortgage broker; she, 32, is a mom (one child, 2). Before the energy crisis they just kept the thermostat set at 76; now they turn it on at 9a.m. and set it at 75 “for awhile,” close the house, close the blinds, “close the rooms and open the closets.” If the days is especially warm she will turn on the AC again at 3. They have ceiling fans in the living room and the daughters bedroom and want more --for their bedroom and the hallway. In the evening they “open the garage to let the heat out,” and open the house between 9 and 10:30 --all the upstairs windows and 3 downstairs, hoping to get a cross-breeze, and leave the house open all night.

She says that she can endure more heat than her husband --he’s more “o.k.” with air conditioning; “I try not to use it.” Because she’s at home she controls the temperature settings. “I’d like it at 72, but if I’m using the AC I won’t go below 75.” 80 is her highest tolerable temperature (“with fans”), and 72 is the lowest, except that they get it as low as they can in the early morning, 68 being the best they’ve been able to do.

She thinks their energy use “is probably typical, but maybe a little more conscientious because I’m home more than most.” If preparing for guests she will turn the AC to 74, “especially with out-of-towners.” The AC is a Rheem of unknown tonnage, and they are “pleased” with it.

She had very little to say about current energy issues. Clotheslines are fine; “we don’t use one but would if the energy bill got really high.” She hadn’t heard of an evaporative or swamp cooler, thought PV is “fine,” thought a whole house fan would be fine “but not here because it’s too dusty.” She hadn’t heard of 20/20.

## **Philip Shriver**

He said that they run the AC “when we’re uncomfortable, as a last resort. We’ll let it run at 75. At night it still doesn’t cool down well. It gets hot upstairs and if I work there I’ll maybe set it even lower than 75; but that’s rare. When it’s 75 downstairs it will be 85 upstairs I’d have an AC just for the upstairs if I could; I believe in spending to save.”

They have two ceiling fans and would like another in their own bedroom. They open the house at night --7 windows upstairs and 4 down. Leave it open all night except for nights when it’s warmer outside. “We considered a room air conditioner for the baby but put in a ceiling fan instead.”

He said that he gets hotter “more easily than Cass. If I’ve done outdoor work on a hot day, I’ll turn on the AC, and remove clothing down to my underwear to cool myself, or go lie on the cement floor in the garage, or put my feet in ice water in the sink -- sometimes when I’m too hot at night I’ll go to the sink. And no covers on the bed. Cass controls the temperature because she’s here and she’s the home economist and economizer. She tells me not to turn the AC on. But I put up with discomfort better than she.” The difference between his ideal temperature and the actual: “I’d keep it at 68, not 75.”

He thinks their energy use is typical, average --“in sync” with the neighbors, some of whom use more, some less.

The AC is a Rheem, and doesn’t know the tonnage and he’s “not really pleased” with it. “It seems to have lost something. We’re from Seattle. Give us air! We’ve gotten more tolerant of the heat but still hate the heat when it gets above 95.” [He noted later than they want to be back in Seattle in 3 years, for the climate and to be near family.] His comfort zone is between 65 and 79; 72 is a good in-between. If they have visitors they will set it down from 75 to 72 “or less, depending on the day.”

He says the temperature at work is ok; he likes to have it cooler “since I’m not paying. People turn it down like crazy, even to 58. The boss complains, but there’s no lock on the thermostat.”

He said he had “many thoughts” about the current energy problem, especially as a threat to the economy. The deregulation was flawed, with efforts to mandate what companies could charge for their product, so that current prices are artificially low. “And now it’s a political problem. California should get out of the power-buying business. I have a friend who’s a lobbyist for Texas energy companies; the legislature let them get away with it.”

He thinks clotheslines are “unattractive --useful but impractical,” but that swamp coolers “are a great idea --my brother has one. PV is also a great idea but I don’t know anything about it.” A whole house fan “would be terrific; I wish we had one. We did put up an awning and will put in a trellis so we can sit outside and it will keep the sun off the windows. But we’re also into Feng Shui and I’m not sure how this would impact. Maybe energy efficiency would be Feng Shui. But if I had to choose between efficiency and Feng Shui I’d choose the latter.” He said he was also interested in energy efficiency as a mortgage broker, and knows the value of insulation; “we have to blow more insulation over the duct work.” He noted that the Feds want “maximum savings for the least money” and that “double-pane windows are way down the list of cost-effectiveness; triple-pane and gas-filled windows are great but too expensive.”

## **Susan Hayden**

This interview was completed by telephone and email, and between the two parts of the interview the story changes. This is another large two-story, two year old, north ElMacero home with a SmartVent. She is a computer consultant and her husband owns an “information” business. When I called her (all of the El Macero homes were from a list given me by Rick Wiley at Beutler, and had SmartVents) she said that my interests were “relevant to the fact that I’m holding in my hand our recent \$600 PG&E bill.” She said that her favorite temperature setting for the AC was 76 and that her husband preferred 73.

“The SmartVent creates a lot of positive pressure in the house. I called Beutler and they said you have to open windows; but that makes no sense because then you let in the heat. One of our neighbors also thinks the SmartVent is useless.” She also noted, with a very disparaging tone, that “its one of those thermostats that operates with a lever.” Later, when we did the email exchange, I told her that most SmartVent users seemed to like them, and asked if perhaps there was an installation problem, and she wrote back: “Actually it was an installation problem. I had them check on it but they still haven’t fixed it. Apparently the thermostat control on the outside of the house is in a metal box that faces south-west, so the box overheats by 15 degrees and throws the entire system off. I wish I could tell you that I liked the SmartVent, but it has done nothing so far and was not installed correctly. Oh well...”

She said that all the rooms have ceiling fans, and all of them run all the time in the summer, and then she emphatically added “the house has too many windows.” In the email exchange I asked her again about this; she replied “If you see the new design of homes there are tons of windows (every side) to let in light. I suppose this saves us on lightbulbs but in the hot California summer it’s akin to living in a hothouse.”

She and her husband have “fought” over temperature preferences: “He likes it cooler, 3-4 degrees, both summer and winter. I control the temperature during the day and he tries to take it over at night, when he comes home.” But later, in our email exchange, she said that after the \$600 bill they had decided to leave the temperature at 76 and to open the windows more than they had been. “The only thing that stops me is a cranky baby who needs to get to bed. Now we open 8 upstairs windows, We would open more but half the windows installed in our home don’t even open!”

She isn’t sure how they compare to others; it isn’t a topic of conversation. She does know that one neighbor “never uses the AC.”

The AC in this house is a Trane whose size, she says, is “about three feet by four feet, and it works fine.”

Her comfort range is “80 --110 in the water-- to 60;” her husband wants it no higher than 76, “and he puts on his shorts at 60.”

If they have “lots of guests” they set the thermostat at 73.

She said she had no opinions about the current energy situation. She thought clotheslines “o.k. but not visible.” She said they had been looking into PV, and want solar panels; “the state will pay half, about \$5000, and they would pay for themselves in a year or two.”

### ***Rachel Mosino***

A two-story, 4 BR south Davis home built in '97 in which they have resided 3 months; she is 41 and a product designer (works at home) for companies that import gift and similar items --birdhouses, dolls, T-shirts-- from China; her husband, 51, is a "codes and standards" administrator for a federal housing program. They have one 10 year old daughter.

They don't use the AC much --"just turn it on when it gets hot, over 100. There have been nice delta breezes this summer, and the master bedroom is on the cool side of the house. There's no west-facing glass upstairs. [But there's a lot of it downstairs, and it was quite warm during our interview not far from those windows.] When she does turn on the AC she sets it at 80.

There are 5 ceiling fans --one in each bedroom and in the family room, used when the temperature is "borderline, the air stuffy." They open the upstairs windows at night, but not the downstairs. She and her husband agree on the temperature matter --"about the only thing we agree on. We have a programmable thermostat but we don't program it --I don't know how. I like it a little bit hotter [than he] when I work here in the winter, and maybe 2-3 degrees cooler in the summer." She said she didn't think they were "average," that they use less energy; but she added that "one of our neighbors used to use the AC all the time, and now doesn't use it at all."

She doesn't know the brand or the size of the AC but is "satisfied" with it. She also made the interesting observation that "the house feels cooler when the AC is at 80 than it does when the house is 80 with no AC," and she noted that if the day was very warm she might turn it a little lower, but never lower than 75. Their last energy bill was "\$100 even."

She doesn't really know about the larger energy situation. "I know there's a controversy, but we're very conserving anyway." She thought clotheslines are "fine. We don't have one but I hang a lot indoors. I dry things a little in the dryer to soften them, but then hang them to dry. Cotton especially. This ought to be a personal issue --they don't want clotheslines but don't care about the junk cars!" Swamp coolers she said didn't appeal to her personally, "but they're ok for others." She didn't have any thoughts about PV.

She also said they didn't pay any attention to the conservation campaigns --partly because they've been in the house just a short time "and we don't have any baseline --we suffer to keep our baseline low!"

### ***Annette Notting***

A north El Macero home, 3200 sf, 4 BR with a SmartVent; she is 37, has two kids, works part time as a lab tech for a private biological research company that does, she says "a lot of fertilizer research." Her husband, also 37, is an electrical engineer for the New Holland tractor company (working on, among other things, the development of electric tractors). When no one is home (both kids in school, at camp, etc. and she working) she keeps the AC set at 86 and when she and/or the kids are home tries to limit its use to late in the day and at dinnertime, just turns it on "and a little lower" (my impression is that she thinks the thermostat is a valve); she looked at the thermostat and said "I probably set it at about 70 for awhile." She controls the temperature settings during the day but her husband usually decides when to turn off the AC in the evening --

sometimes when the Vent comes on, which is also usually close to the time when they open the windows. [I asked if the vent coming on was used to indicate when they opened the house, as another interviewee had said, and she said “Yes! My husband does that!”] She indicated that at first the SVent wouldn’t run very long and didn’t seem to do anything, but then her husband got into the literature on it and now it runs most of the night and the house is often “quite cool” when they get up. They leave the upstairs windows open at night but not the downstairs, for security. She closes the windows about 10 a.m. They have four ceiling fans and she said they were very important in keeping the mid-afternoon house comfortable.

There are differences between herself and her husband about temperature preferences --she likes it cooler (“I even like fog --he hates it.”), but “he has used the energy crisis to make me warm the house up.” Ideally she would keep the house “a little cooler, but I can’t put an exact number on it --maybe a little funny for someone who works with numbers all the time.” I asked her if she liked it when the house got down to 70 and she said yes, and that the morning cool is fine with her.

She thought their energy use probably average --some people she knows run the AC all the time and some really avoid it. She “guessed” that her temperature “comfort range” would be about 60 to about 76, but she knew that on some afternoons it got warm in the house, but she could tolerate that “for awhile” because of the fans and because she knew it would cool down later. She said that if guests were coming even her husband would make the house cooler.

The temperatures at work vary somewhat, she said, depending on the research going on in her area, but it never got so warm that she felt really uncomfortable.

She said she assumed the current energy situation was serious, but didn’t know how to improve it. Clotheslines would probably be ok but they didn’t have one; she didn’t know about swamp coolers but said that her husband was “excited” about photovoltaics (“Isn’t that where you use the sun to get some of your own electricity?”).

They have done a little to try to conserve other than keeping the house a little warmer --had moved the laundry into the evening, for example, because one of her kids had told her that that was important.

## **Appendix F – Gold River Interview Notes**

The following interviews were conducted in the Gold River area, east of Sacramento, by Bob McBride.

### ***Lisa Kim***

The Kims have lived in their 2 story 2000sf house for four years, since it was built. Lisa is 45, husband Ken is 46, and daughter Sandra is 16. Both parents are first generation U. S. citizens, born in South Korea. Sandra is a typical teenager, except that she plays piano with considerable skill and feeling (I've heard her practice). In the summer, they typically set their two-zone air conditioner at 83 degrees F. They've installed 5 ceiling fans in the house, and they have 2 reciprocating fans for the rooms without ceiling fans.

If the evening is hot, the house stays closed, but if it's cool I open windows upstairs, and the slider downstairs about 5 inches, using it's security pin. The other downstairs windows stay closed for personal security.

Lisa and Ken usually agree about temperatures. They have a programmable thermostat (Beutler) but use it manually. Lisa's ideal temperature would be 75 degrees, and she feels that 73 degrees is too cool in the summer. Lisa considers her approach to cooling as average, after talking with coworkers about it. She does not know the size, EER, or brand of the AC, but said it must have been built before 1997.

Lisa's range of temperatures is consistent with her thermostat setting and stated ideal, ranging from 75 to 83 degrees. Without fans, she expects that the highest she would want is 80 degrees. When she exercise, she uses the fan and sets the AC to 75 degrees. When they have visitors, she sets the thermostat to 80 degrees.

Both Lisa and Ken work for the Postal Service, who she says doesn't use any AC this year. The temperature at work is maybe 85 degrees. Before this year it was cooled so much they wore jackets. As you might expect, she is not satisfied with the temperatures maintained at work. Employees are not involved in setting thermostats.

Lisa says "we don't have enough power" (meaning energy or capacity, not political power), and that it's "kind of serious". She says she doesn't know who is responsible, but that the media is very involved. (with creating the perception of crisis?) She explained, "I don't want a high bill, I want to pay what I used to pay". She continues, "the State is responsible, it's a political problem (Governor) Davis gets blamed but is was Wilson's problem. They'll probably buy some power from other states, and maybe Sacramento (SMUD, or perhaps the State Gov't) will get more generation going.

Among the four energy conservation measures, clotheslines, Lisa thinks, are practical. She hasn't heard of evaporative coolers, and has heard about photovoltaics but not much. Their house does have solar shade screen on the West side, to limit the effect of afternoon sun. They have not added any conservation measures this year, however. Compact florescents, I noticed, are common in their house. She would not be interested in the follow-up study.

### ***Ken Kim***

The Kims have lived in their 2 story 2000sf house for four years, since it was built. Ken is 46, wife Lisa is 45, and daughter Sandra is 16. Both parents are first

generation U. S. citizens, born in South Korea. Sandra is a typical teenager, except that she plays piano with considerable skill and feeling (I've heard her practice). In the summer, they set the downstairs of their two zone system at 83 degrees. They don't use the upstairs zone thermostat, Ken says, "because if we do, the AC keeps running and running in hot weather. Only in the evening, we turn on the central (system) fan on the second floor to move hot air outside with the windows open."

Ken has installed five ceiling fans, three upstairs and two downstairs, in addition to two oscillating fans. One oscillating fan is used for exercising, and the other upstairs aimed where someone is. The time of opening windows depends on the temperature outside; on 100 degree days, they open windows at about 10pm. Also, Kim turns out the upstairs central fan at about 1am when going to bed. When they get up in the morning, they open windows on the shady (West) side. The downstairs front window is never opened, for security.

"If it's hotter," says Ken, "of course I change to lighter clothes." The family is about the same with regard to temperature preferences. "Lisa and Sandra", explains Ken, "don't worry about the settings. I'm thinner and am more sensitive to temperature." [To my perception, however, Ken and Lisa have similar body types, meaning weight and body fat.]

Their thermostat is programmable, but Ken (a PC user and his own system tech, in that he changes hardware and fixes problems as needed) uses the "manual **SETUP**", "because it's easier". [I don't believe for a minute that the terminology "SETUP" is accidental. On open-architecture PCs (such as those that run Windows but not Mac, like Ken's), SETUP is the tech-only interface for adjusting BIOS to current system hardware, which is not unlike a minefield for the average PC user. Nonetheless, a minefield occasionally crossed, since home PC users must pay a tech for this level of support.]

Ken's ideal temperature during the summer heat -- which I have been explaining as what temperature one would use if energy were free -- is 78 or 79 degrees. He doesn't know opinions of neighbors or coworkers, because he hasn't asked anybody. When I asked what size his AC is, he replied: "What do you mean by size?" No also to what EER. He thinks the AC must have been build in 1997, since they moved into the house when new.

When asked about a range of temperatures, Ken volunteered for a high temperature that "80 is most comfortable, but 83 is okay if the ceiling fans are on." "We keep a blanket by our feet (on summer nights with windows open). He has closed the window at night because of cold maybe five nights a year after having opened it for cooling, but is not sure of the temperature. [I'd guesstimate, being located nearby, that it falls below 60 degrees at night on more than five nights (but on less than ten nights) a year after hot summer days, so that Ken's low must also be below 60. Note: I could with modest effort check NWS data for the closest station and see; is anyone interested? We would be topographically between Mather and the fish hatchery at Hazel and the American River (two likely weather stations).]

When they have guests, they bring the temperature from 83 to 81 or 82 degrees, with the ceiling fans on. "Ceiling fans are very useful for cooling." Ken had a contractor install solar shade screen in 2000. "Without the sun shades, it was very hard to stay upstairs in summer." Ken said to me, "your job is critical, everyone needs to change how they use energy." So he seemed to perceive that this project serves a public education



function. Referring to something he heard in the media, he said "German people wear very heavy clothing in winter, they're very thrifty."

At the USPS SCF facility in West Sacramento, where he works, Ken says they have the thermostat higher, so many workers complain about it." He goes on to explain that most postal workers do hard physical work, but that the maintenance workers, who set the thermostat, "are sedentary".

Ken feels that the current energy situation in California is very critical. The previous Governor's team is responsible. He had heard the day before the interview that "they created free market pricing so that prices would be lower, but they were wrong. The solution is that everyone needs to save energy on their own." When asked what should be done, Ken said "I have enough trouble controlling my own house, managing that problem should fall to experts who have knowledge." But he then volunteered that "some people will save energy, and others won't. The big consumer deserves a higher bill."

Asked about clotheslines, Ken paused for a long moment, and said "I don't know. I was thinking of getting a (portable) clothes rack for outside, but clotheslines are ugly. I don't like to show my underwear to the world." He has read about evaporative coolers in the Bee, but has never experienced one. He points out that by using outdoor air, they make the indoor air cleaner than an AC which just recirculates. Photovoltaics are "very attractive and practical." He has installed solar shade screens on the West side of the house, but that was before 2001.

Since the energy crisis started, Ken pulled the plug out for appliances -- TV, computers -- when not being used. We raised our temperature from 82 to 83 or 84 -- depending on the outside. "If the outside temperature goes much higher, we raise our indoor temperature to avoid health problems. If the difference is too much, we can get health problems -- colds, or change our biorhythms -- I heard that from the media. If outside is 110 (degrees), I feel okay with 84 inside, if the ceiling fan is on.

Ken says yes, that he's interested in a monitoring effort.

### ***Kathy O'Donnell***

Kathy, 36, husband Steve, 35, and their son, 8, and daughter, 6 moved into their one story 1500sf three bedroom house four years ago when it was built. Kathy is a clerical supervisor and husband Steve is a journeyman printer. The house has AC, and they use it "when it's hot". Their thermostat setting is 73 degrees, and they either turn it off or up to 78 at night.

They've installed a ceiling fan, and open the house at night. Kathy changes clothes according to the weather, and was wearing shorts and sandals when I interviewed her. She has fallen asleep on the couch and left the front door, which has no screen, at night.

Kathy gets cold faster than Steve, and said that if she walked into the house just now, she'd turn the AC off. As we were talking Steve came home, and we shooed him away because I plan to interview him later. Kathy said that whoever's home controls the temperature settings. "Austin even knows how," she comments of her 8 year old. If Kathy gets colder, she "uses the excuse to go to sleep early and get under the covers." They have the standard programmable thermostat for the neighborhood, but don't program it in summer.

Kathy thinks others are “more conservative” than her family, in context meaning more likely to conserve. But she thinks of herself as average. She is not aware of the brand, size, or EER of her AC, but says “I’m fine with it.”

Kathy’s comfort range is from in the 80s (‘high’, she added) to a low of 68 degrees. When I asked whether she ever closed a window at night because of cold during the summer, she could think of two times this summer. Again, I’m sure she’s been exposed to below 68 degrees at night without being aware, without any problems. They have not changed the settings for guests.

She works in a County office, and thinks her comfort requirements at work differ from those at home. “At work, I’m hot, always. The room has no vents. We use fans.” She is not satisfied with the temperature setting, and says employees are not involved with the thermostat setting. She follows with a funny little vignette, that little cages were put over the thermostats because of ADA, since people in wheelchairs couldn’t reach them. Nonetheless, a paper clip can be used to change the setting, even though nobody’s supposed to touch it.

Kathy has no judgement about whether the energy situation is serious, but says “somebody must have paid off somebody, and used (budgeted) money wrong.” As a result, they failed to find out how many power plants were needed. Her sense of the problem was misappropriation, but is not sure what should be done. She expects that “they’ll open a power plant or two.”

Kathy likes clotheslines for sheets but not for socks and underwear because they get too stiff. When asked about swamp coolers, she poses “don’t they cause mold?” On photovoltaics, “sure why not?” We had them for my mom’s pool, and now her brother uses them. They’ve not added any conservation equipment since moving in.

When I asked how much her last SMUD bill was, I was shocked, given her thermostat setting, that she said \$66. Even though their house is somewhat smaller, after adjusting for size this is still a modest bill. Their thermostat setting was low, 73, but they only use the AC when it’s hot. Hot, in this case, must really be hot. [And she thinks of herself as conserving less than her neighbors... I compare this with another set of neighbors who think of themselves as stout conservation advocates, with a larger SMUD bill, even in proportion to size. Self-image regarding conservation appears more style than substance.

### ***Grant LeFevre***

Grant, 67, and his wife Reese, 35, have lived in the newer 2300sf two-story “Slate” model for three years. One son, 16, is at home, and a daughter is away at a California State University, so there are now three people in the house. Grant administers public and other funding for Arts programs, at a state agency.

They have a two zone system with the standard AC for the subdivision, which they do use. When they’re out of the house, they set the thermostat to 80, and an hour or so before they get home, 78 or 79. They do use the programming functions, but turn the AC off manually when they open the windows at night.

Grant installed three ceiling fans, which they use when they're at home. The two upstairs stay on all night, since they're in bedrooms, and the downstairs one goes off when they go to bed.

Overall, Grant is impressed with the ability of the house to maintain a temperature, noticing that once achieved, the AC rarely goes back on. [This could be because they are very close to the next house to the West, which shades the stucco side of the house most from mid-afternoon on, leaving only the concrete tile roof exposed. The house has a lot of tile in the downstairs floor, so the uninsulated slab may also cool the downstairs.]

They generally live with the way they've agreed to set the thermostat. Occasionally, Reese gets cold and grabs a blanket. Grant says his ideal temperature is what they do, since the bills haven't been any higher than their last house, which was much smaller. Again, Grant mentions that the house is easily stabilized at a temperature, since it's so well insulated.

Grant at first says "I can't comment," when asked if he thinks he's a typical user of his cooling system. Then he observes that his older brother and sister, who have health problems, keep their place very hot, especially in winter. Then, Grant says, "I'm probably average." Like most, Grant is not aware of the size of the AC. When asked the brand, he says "I think it's Payne... no, that's my old house. Since they moved into a new house, Grant knows the AC was new in 1998. He is quite happy with it.

The high end of Grant's temperature range is 79 or 80, but if he's doing something active, he'll cool more. He estimates the low temperature of his range to be 69 or 70, but then when asked if he ever closed his windows at night, he says "No, we have two covers on the bed and just use the heavier one when it gets cold." Grant does not change temperature settings for guests, although he expects that he might if an older brother and sister visited.

Grant works in a State building, where his comfort requirements are basically the same as at home. About 80% of the time he's satisfied with the temperatures centrally set for the large building, which he has no control of. When they cycle the AC it gets too warm.

Grant judges "It could be an energy problem, but people who are controlling the flow of energy are maximizing their profits. The chain of people who profit are responsible." Asked what should be done, he says "When there are sudden shifts in price, people should limit their use." About what will be done, Grant expects that alternative sources of fuel and energy will take over or reach a level where they're competitive with fossil fuels. Also, research will be done into speeding up the alternatives.

Grant says he hates clotheslines. "At my old house we had one, but it wasn't visible from the street. My yard here is too visible." Regarding 'those swamp coolers', "My sister used to have one – they get real funky and breed mosquitoes if you don't take care of them. If you can't afford more, you should have them." On photovoltaics, "Yes. Clean. Problem is, where would you put storage batteries, since sulfuric acid fumes are a health problem." [an excellent point] Grant hasn't added other conservation measures.

Grant says his behavior hasn't changed, but his office had a drawing contest for kids on an energy conservation theme. The Governor's wife was among the judges, and the winners were made into posters.

## **Ronnie Montana**

Ronnie and husband George, both 42, moved into their 2-story house of about 2100 sf about one year ago. They have girls of 14 and 8 years old, and a boy, 12. George works in the building trades, and Ronnie worked in a personnel office until moving here, and now works only a short stint daily at the local elementary school as playground supervisor. They have the standard AC built into these homes with one zone, and use it at a constant setting of 80 degrees.

The house came with one disfunctional ceiling fan installed, which they fixed by wiring it correctly, and they have two portable fans. Since the house has a backyard pool, using the pool is part of their cooling strategy, and have added an awning to create a shaded backyard area for a patio table that also shades one window. They open the window for the master bedroom whenever it's cool outside, and the window in their younger daughter's room. The older kids have taken to closing their doors at night, so the benefit of opening their windows is lost, since there's no cross-ventilation. However, in the morning Lonnie opens all windows until the sun hits them, or it gets hot. They all change clothing to reflect the day's conditions, and use the pool to cool down whenever it's too hot, rather than lowering the AC setting. When asked, she said they're not much concerned with security, except for closing the patio slider at night, also in order to keep their dog out.

When George comes home (5 or 6pm), in the hottest part of the day, he'll leave the slider and it's screen open, which is more an unconscious behavior than any sort of preference. Otherwise, their preferences are similar, or at least negotiated to their current behavior. They do have a programmable thermostat, which they program to a schedule in winter but not summer. Ideally, Lonnie would set the thermostat maybe 3 to 5 degrees cooler, if energy were free. Lonnie thinks of herself as similar to her neighbors and friends, "probably similar".

The size of the AC, it's brand and EER are all unknown to Lonnie, but had heard of the brand because she looked into it when they bought the house. She says "I'm pleased enough with it, it works." When asked, she said their last SMUD bill was \$220. [Even though their thermostat setting is rather high, not turning it off when absent extracts a large toll...] Lonnie mentioned that she had heard that turning it off means the heat stored by the building has to be cooled later at the same cost anyway. This model of reality is logically reasonable but flawed enough in reality to cost them quite a bit.

Lonnie initially stated her temperature range was from perhaps 80 down to 70 degrees. After considering that their thermostat is downstairs, and that the upstairs was often higher, and that she felt decidedly uncomfortable when it hit 83, she adjusted the upper bounds to 81 or 82. I asked whether they ever closed their window at night because of the cold, and she said never. I've observed that the nighttime low is commonly around 59 to 61, and that our own similar house ends up from 63 to 68 by morning. We concluded together that the 70 degrees she stated was the actual cooling typically achieved inside by morning with the windows open, but that she probably had experienced cooler temps with no problem.

They do turn the AC off and allow it to get warmer by a couple of degrees, when Lonnie's mother in law, who has a long-term illness, visits.

In her former job, Lonnie was too cold at 72 degrees sitting at a desk, so she'd wear sweaters. Employees had a voice in the setting, but some of them liked it colder than she did.

Lonnie thinks the energy situation in California is serious. She generalized that whoever is in charge doesn't ask the right people. Her example is a big company she worked at where one work group had to be moved. The company redesigned the layout without talking to the workers involved, so the results were crowding and (my phrase) generally anti-ergonomic. "Some experts probably said there was a need for power plants or solar or whatever, and they were ignored." They should plan 20 or 30 years ahead. They'll probably end up spending the most possible money and doing the cheapest possible thing.

Lonnie has considered a clothesline for sheets and blankets, but likes the clothes soft. She saw in K-Mart an umbrella stand-type clothes rack, and still considers it. They hang their pool towels over the patio furniture currently, but none were in evidence. She hadn't experienced an evaporative cooler. She asked if they were any cheaper (than AC). She doesn't like stuff hanging out of the windows, because it gives the "boarded up look". Together we speculated whether there in-attic designs that vent air in less conspicuously than a tan box on the roof. Regarding photovoltaics, she says she knows there's quite a few around, and "I think they're a good thing but didn't want the expense -- she said it'd be nice if they built it into a new house, cheaper than a retrofit (referring to spreading the payments).

They've purchased horizontal 2" wood blinds for inside almost every window since they moved in, and the patio awning. Asked about the CEC/utility media campaigns, she says "we've been through an energy crisis before, and know the drill." But, she said, it's a matter of attention or laziness. The kids still leave the TV on, even if the game station or cable box is turned off. She feels that the media campaign has had little new effect -- other than reinforcing what she was already doing.

### ***George Montana***

The Montana family has lived in their two-story, roughly 2000sf house for one year. They have a one-zone AC which they use by setting it at from 80 to 82 degrees. They supplement their cooling with five floor fans, jumping in the pool, and opening their windows at night. They close the downstairs slider at night to keep the dog from destroying the screen. George doesn't seem concerned about security: "I pity the sucker that tries to climb in our bedroom window." [George is about 6'4", maybe 240lb.]

Regarding differences among the family, George says "I'm the most tolerant, so I go with everybody else. I take it as Ronnie has it." George says the thermostat is programmed, but he's not sure of the times it's set to -- he offers to have me look at it, but we later forget. He says "Ronnie does the main control." His ideal is no different from actual temperature settings, "I don't like the drastic change of (outdoor) heat to (indoor) cold."

George considers himself "average" when compared to his neighbors, friends, and co-workers. Asked the size of the AC, he says "I forgot. I did know." Same for the EER, but he identifies the brand as York. He estimates that the AC was built and installed in

1997. He would like to look into a different model -- "York has a model, the "Mighty Midget", that's about half the size and half the power consumption.

George estimates his temperature range as 75 to 90 degrees, but he says he never closes the bedroom window on summer nights (which frequently go below 60 degrees). He hasn't changed the temperature for guests.

Asked if his workplace comfort requirements are the same as those at home, he says "Impossible. I can't drink beer at work. I do finish work on unfinished houses, so there's no electricity even if the AC is in."

Asked about California's energy situation, George says "I think someone dropped the ball years ago." Then he refers to an "Embargo on building more power plants. He says "Ignorance and environmentalists are responsible." Doesn't think he knows enough to say exactly what should be done. Then, he says "At a guess, a publicly owned co-op of some sort might work. I don't want co-ops in medicine, I want the best doctor, not the average. But power is power. Asked what will happen, he says "they are making some power plants -- I don't know if that is the whole story."

Clotheslines -- "Sure, why not? Regarding swamp coolers, he says "Great for camping, but they put off too much humidity." We discuss the difference between San Jose and Sacramento, and then he says, yeah, maybe they'd work better here. On photovoltaics, he says "the initial cost has kept me away. George has installed a backyard awning, which shades an area for a table on the patio, and one window. He's considering a Gazebo (away from the house), and window shades.

Asked about the effect of media campaigns, he says "we have been as conservative as our lifestyle allows, and do what we've done for years."

### ***Martin Stanton***

Martin, 50, wife Liz, also 50, and daughters Janet and Allison, both 9, live in a 3100sf two-story home in a Gold River 'village' for three years. The homes in this village have wood siding and shingle roofs, and were built in 1986. Martin says they have two ACs and two zones, one on each floor. They rarely use it nowadays. "We used to, when we could afford it. If we're here, during the day we don't use it if we can lower our body temperature in other ways. When it's on, we set it to 85, but it's normally off."

After moving in, they added three ceiling fans and this year a whole house fan. They open the windows at night and into the early AM hours. For security, they close the downstairs windows at bedtime.

Martin says there aren't differences among the family as to temperature preferences. Both he and Liz control their various devices. They have programmable thermostats, but use them by keeping them set to 85 and turning them on and off manually. Ideally, Martin would set the thermostats to 65 (at the time of the interview, the temperature was 95 outside).

Compared to neighbors, Martin feels they use a lot less cooling. If he steps outside, it could be 75 degrees with the sun down and the next door neighbors have their AC on. He says, "I don't think we're average or typical."

Asked the size of the ACs, he identifies the upstairs one as two ton, and the downstairs as 'three or four ton', but does not know the EER. He estimates that they are

fourteen years old. Asked if he's content with them, he says, "I don't know enough about new models."

Martin's temperature range runs from 85, with a fan, down to 65. If they have a large group over, they are most likely in the backyard (which has a custom pool, hot tub, patio, and lawn) they turn the AC off so it doesn't come on because the sliding door is usually left open. If Martin's mother-in-law (who lives in Phoenix) comes over, they set the AC to a lower temperature.

Martin runs a food service ending machine business for a public facility and has a small storage warehouse that has to be kept at 72 degrees to preserve the perishable foods. The job involves wheeling supplies around on foot outside, and by truck, and doing inventory in the warehouse, so the thermal environment varies a lot. Martin controls the temperature in the warehouse, and is satisfied with this arrangement.

Asked if the energy problem is serious, he says "Sure. Because of poor power contracts done with out of state providers, we're subjected to enormous price increases." Asked who's responsible, "Everybody points a finger at everybody else. The Governor, because he's responsible for procuring contracts. Power suppliers because they took advantage." Asked what should be done, "State and Federal government should push subsidy and tax incentives for solar devices, to be added onto and built into homes, to aid them to be self-sufficient, potentially an energy supplier." Asked what will happen, "New power plants will be allowed to proceed, in exchange for past environmental concerns."

Asked about clotheslines, Martin says "I'm for it. We haul our laundry outside and hang it on patio chairs, 90% of it." On evaporative coolers, "I'm all for those – I grew up with one, and a house we built had one built in. It was a Goettel 'piggyback' evaporative cooler and refrigeration unit." Photovoltaics are "a great idea, but too expensive right now. If California energy prices go up, maybe they won't be." Martin and Liz have added a whole house fan and ceiling fans, and a new concrete tile roof with a 'thermal ply construction'.

As a result of the media campaigns, they've started drying most of their laundry outside, and do more cooking outside on their gas grill (instead of their electric range), which Martin points out also reduces the house's heat load. He's reprogrammed their pool pump to run at night, and for half as long. Martin turns his computer off more.

### **Max Blueberry**

Max and Sally moved their family (including Rosylyn, 9, and Damon, 7) into the two story 2500sf house three years ago. Max manages an environmental consulting firm and Sally is a personal financial planner, and most days no one is home until about 5pm. Their AC is part of a two-zone HVAC system typical in the subdivision. The system comes with a two programmable Beutler thermostats, of which Max says their settings "vary, because the damn program, I swear the thing don't work. I turn it up 5 or 6 degrees when I leave, unless my 'CRS' kicks in." Like a comic straight man, I ask, "what's that", to which Max delivers the punchline "Can't Remember S--t". [CRS is certainly a key characteristic of Folk Quantification.] So, in the evenings he sets to 78 degrees, and up to 83 during the days when no one's home.

Sometimes at night, when it's hot outside, he'll turn it down to 76 degrees. If it's cooler, I'll open windows. I would sleep with windows open, he says, except for the freeway noise. Aside from AC, the main cooling tactic is to open the house at night. "I want to get fans," he says, "but I just haven't done it." Max's clothing differs from winter to summer, but stays with gym shorts and tees at home most of the summer. He uses their small pool when hot. Due to security, the downstairs windows stay closed at night; also, the kids like their (upstairs) windows open a crack.

Max says there are few differences among the family with regard to temperature settings or how cooling is obtained. Nobody "futzes" with (the temp settings). There's some conflict -- say, someone comes in from the pool and is cold, or has been working outside and it's hot.

Here, Max says "I leave it on because in theory it takes more" (energy to recover). Also, he'll cool more downstairs in early evening, and upstairs later, since that's where the people are. There's no difference between Max's ideal and actual settings. Asked about how they compare to friends and neighbors, Max says "never thought about it. I think they don't conserve." But then, when asked if he considers himself average or typical, he answers "typical". [It occurs to me that people may consider "average or typical a choice, of which you're supposed to pick one.]

When asked the size of their AC, Max says jokingly "about 3' by 3' by..." Likewise, he was not aware of the brand, but estimates the year it was built as 1998. Regarding temperature range, Max estimates from 82 or 83 down to 66, "if I have quilts". Max will change the temperature if older guests arrive, by moving the setting up a degree or two.

Where he works, Max likes it colder, "... to stay awake. I have a hot office. My office is okay, but others complain to me. I can, but don't change it."

When asked how serious the state's energy situation is, Max says "Real serious. Criminal behavior is going unpunished. The crows are coming home to roost and the public's in denial. The Governor is worried about campaign contributions, and has a split allegiance between the democratic public and the corporations." When asked who's responsible, Max says "Everyone. It's the sum of everyone's sins. Greedy corporations, the legislature did a half-assed deregulation, and the public says NIMBY. But #1 is corporate greed." Asked what ought to be done: "Public power -- buy the grid, buy the plants, condemn 'em (meaning inverse condemnation), pay 'em off. Re-regulate, split the difference (between recovery through rates) with maybe 20% bond. Deregulation has failed. Half-deregulation failed worse.

Asked about clotheslines, max says "No, for me they're not useful. It's the lifestyle, we're too busy." Evaporative coolers are "Fine by me." But he says he's never experienced them. Max answers "Sure," about photovoltaics, I'd buy them with some tax credits." Max says they have not added any conservation equipment since they moved in, but I notice "shade sails" in the back yard that cool the patio and shade the lower story south windows. Their small pool is not heated, also. They have installed window blinds inside. Max has noticed the effect of the media campaigns at Costco (half the lights are off) and most grocery stores. He's talked with the kids about turning the lights off, and they have turned the thermostat up a couple of degrees this year. Also, they run the pool pump fewer hours.



## **Sally Blueberry**

Sally and Max Blueberry, both 43, and kids Rosilyn (9) and Damon (7) have lived for three years (and two months, says Sally) in their two story, 2500sf home. Sally is a personal financial planner, and Max an environmental project manager. They have and use their AC, with the downstairs set from 78 to 82. Sally says it is a two-zone model, but didn't offer how the upstairs is set.

To cool themselves in the summer they also drink ice water, and jump in their small above ground pool. They open windows at night, using the fan without the AC. They also take cool showers or wear less clothes to get cool.

Sally gets cold when others are still trying to get cooler. My notes don't say whether this results in conflict, or how they cope, but I plan to interview Max. Sally considers herself typical of neighbors and coworkers with regard to her cooling behavior. She's unaware of the size, brand, and EEC of her AC, but figures it dates from 1998, when they occupied the house as new. She said "I like it", again referring to the AC, with comic expression.

The top end of her comfort range is 84, which I presume to be how hot the upstairs gets when downstairs is set to 82. Her initial idea of the low, 78, turned out to be the lowest temperature she would cool the house with AC. After asking if she ever closed windows at night because it was too cool, she settled on 65 degrees. She does not vary the temperature setting for guests.

She responds that at work, she has the same cooling requirements as at home. When asked if she's comfortable with the temperature settings at work, she exclaimed "NOT!" She goes on to explain that the office area is divided into two sections, and due to the quirks of the building and system, one is always hot and the other always cool. Nonetheless, employees are able to set the temperatures, it's just hard to get it right.

The energy situation "seems pretty serious", according to Sally: "blackouts, bankruptcy, can't be sure how much is energy and how much is politics. When asked who is responsible, she says "we're all responsible", and "bad political decision-making". Her solution is "full disclosure, (have everyone tell) what happened and why", and "continued education, selling the idea of energy conservation". Asked what likely will be done, she expects "more finger-pointing".

Sally has taken to using her balcony rail to dry clothes, and thinks the use of clotheslines is a good idea. She says of evaporative coolers "I think they're maybe less efficient, but I was never exposed to them until I moved to Sacramento." They moved to Sacramento from San Jose when buying their current house. My impression that by "exposed to evaporative cooling" she means "heard of, or aware of", and that she hasn't directly experienced one. Sally likes photovoltaics, but feels that they're probably not practical. They haven't installed any additional conservation devices, except that I notice curtains on the several windows.

The media campaigns for conservation have caused them to "reduce lighting, and be more conscientious about it, although they were doing that before."

Sally says to ask whether they're interested in our further activities, but says she's too busy currently.

## **Mort Thomas**

The Thomas family has lived in their two-story, 2500sf home since it was built in 1999. Mort and Diane, both 41 have four children: John, 13, Shannon, 9, Andy, 7, and Joshua, 5. Mort is a business analyst for an electronics firm and Diane is kept busy at home. They use their two-zone AC, keeping it set to 79 or 80 degrees. Diane avoids using it until afternoon, and if it's exceptionally hot, they may turn it down to 78 as needed.

To supplement the AC they use six ceiling fans. Diane opens the house in the morning to cool, and closes them when the temperature outside hits 80. If it's hot, the fans and AC are on earlier. They've also installed shade sails in the west-facing back yard, which create a shaded patio space and also shade the lower story windows there. The backyard also has a pool. Mort will dress in tee shirts and shorts most of the summer, and I noticed he was wearing athletic shoes and gym socks, today being a mild (circa 80 degree) day.

Mort gets hot sooner than Diane, due to his home office being both upstairs and on the west side of the house. This happens sooner if someone has left the slider open after being in the pool. Diane will notice that Mort has turned the AC on, and mention it because of the cost, not because she's cold.

The thermostat is programmable, but they use it manually, by changing the temperature setting. Mort figures that his ideal temperature would be "a few degrees cooler". Compared to neighbors, friends and co-workers, he considers himself "probably fairly average, with the exception of the fans". He's not aware of the size, EER, or brand of the AC, but says it's two years old.

Mort estimates his comfort range as from 80 to 68 or so. When I ask, he says that the 68 would be the lowest setting of the heater in winter, so I ask if he's closed windows at night. He says yes, and that he may already have turned off the fans. Perhaps his 68 degree estimate is accurate.

For older relatives, Mort has turned the AC on, lowering the temperature a couple of degrees. [The only case of lowering the temp for guests that I've seen.]

Mort works both at home and his company's building, which he describes as cooled to about 68 degrees because of the electronic equipment. "We're usually cool and trying to go out to other areas. Employees are not involved with setting the temperature, the needs of the equipment overrides that."

Regarding California's energy situation, "I'd say it's serious." Asked who is responsible, Mort says "One, us, all of California; two, state government; three, energy suppliers." His long term solution would be to build some nuclear plants and augment them with renewables. (One of their parents is a retired engineer that worked on nuclear plants.) He expects what will happen is a short-term fix of gas-fired plants and that prices will stabilize, and we'll live with the status quo until the next crisis.

Mort is not sure how the family would adapt to clotheslines, because he doesn't do the laundry. Evaporative coolers "are okay, but they blow in other contaminants and you end up with mold." He expects that photovoltaics "are not going to give me much of a return." They have installed ceiling fans, shade sails in the back yard, and blinds inside the windows.

The media campaigns have caused them to defer laundry, even though they have a gas drier. Also, they've unplugged some outdoor decorative lights, and use the pool pump two hours less that last year, and run it in the morning, off-peak from 6am to 11am.

### **Liz Stanton**

Although coy about her exact age, 'Liz', an attorney by trade, agreed when I suggested 50. Husband Martin is the same age, and owns a small food service business. Daughters Janet and Allison, are both 9. The family lives in a two story 3100sf planned development single family home for three years. The homeowners association is responsible for front yard landscaping and the house exterior (shake siding), except for roofing (also shake).

The house has two Acs and two controllers, which they use on some of the hotter days. "I used to set (the downstairs) for 80, and now I set 82 (degrees). The upstairs is set at 85. They've installed four ceiling fans, "I think," says Liz. They open the upstairs all night, and the downstairs in the evening until bedtime, for security reasons. When she comes home from work, she changes into tees or sleeveless shirt, shorts, and sandals. All, but Liz the least, jump in their pool as soon as they get home, to cool off. Liz doesn't use the pool as much, but she "can tolerate a little warmer than Martin, and the kids don't get a vote. They occasionally say 'I'm hot', and we say 'go in the pool'.

"Whoever (of Liz and Martin) gets there first controls the temperature settings (downstairs), and then the other changes it. Whoever walks by has control -- mostly, we haven't used it this year." She reports occasional conflict. Liz doesn't know if they have programmable thermostats -- "I don't think it is. Anyway we don't program it."

Liz's ideal temperature, which I describe when asking as 'if energy were free', would be 78 'for just hanging out', and if active, the low 70s, both without fans. With fans, 80 if sedentary and maybe 75 or 76 if active.

Compared to neighbors, friends, or coworkers, Liz says "We are willing to take a little warmer, even last year. But especially this year. We probably conserve a little more than most people here." She didn't know the size, EER, or brand of her ACs, but guessed that EER meant 'energy efficiency rating'. She assumes that her ACs were installed in 1987, when the house was built, and would prefer a different model, because "the newer ones are more energy efficient".

To describe her comfort range, Liz quickly said that 82 was the upper limit, but pondered and then 'we never close the windows at night', meaning during summer because of cold when the next day is expected to be hot. When pressed for a number, she suggested 55 as her lower limit. When guests are coming, they make it cooler, maybe 76 or so.

At work, Liz's comfort requirements are a little cooler than at home, and she is satisfied with the conditions at work. 'Grunts', as she describes herself, are not involved in setting temperatures at work.

Liz characterizes the California energy situation in 2001 as a significant problem, but not what she'd call serious. "We're doing fine, we're using less. A lot of things conspired to make a problem: the population was using too much, the city planners for not controlling growth, utilities, power generators, politicians, electronic manufacturers. Nothing is done by hand, everything has to use electricity. To me, the dumbest thing in the world is an electric can opener. Not that it uses that much..." Asked about what

should be done, Liz rattles off 'conservation, solar and alternative energy sources'. Asked about what will be done, she smirks and says 'I don't know, Bush will drill a lot more oil wells.'

Clotheslines, Liz says, are unattractive but practical. "We bought two laundry racks but they broke -- they were made cheaply -- and now we're just using lawn chairs." Evaporative coolers, she opines, can be practical, if a little ugly, but there are times when they help. "We're actually thinking about it," meaning photovoltaics, "we have a form to fill out. It sounds like they're very practical." They have ordered a whole house fan, which should be coming in next week. Also, they've added some bamboo screens outside, 'not solar screen', and have (primarily decorative) shutters inside.

The conservation media campaign has caused them to do laundry 'all night', and turn computers off during the day. "I turn off the monitor and printer. We haven't used the spa, have shortened the hours for the pool and spa filters, and they're now off peak." Asked about the future plans for our project, she says "Sure, yes."

Liz made an interesting point, that the SMUD bill no longer shows the energy use for the same month in the year prior, although I notice that my own SMUD bill retains the "Prior Usage" table, but only lists last month's usage.

### **Satpal Mukherjee**

Satpal, 38, a computer engineer has lived four years in a 2 story 2280sf "Granite" model home in the Gold River Station neighborhood. He now lives alone. The house has AC with a two zone system, but he uses only the upstairs zone manually to cool to 83 degrees. "If the wind is blowing, I'll leave windows open." Last year he cooled to 79 or 80 degrees. He chose to do this before it got hot this year, meaning that it was in anticipation rather than in response to a high SMUD bill.

Three ceiling fans were added, along with one pedestal fan. He goes to bed really late, which allows him to notice if the temperature is going to drop and open the windows. He checks it out at ten p.m., but some nights are too hot all night. He emphasizes that he prefers fresh air.

Satpal's ideal temperature is 79 or 80. The thermostat is programmable, but he uses it manually. If there's a high forecast, say 100 degrees, "I close windows and set the upstairs to 85."

Compared to neighbors or coworkers, "I'm a little more conservative -- I hear the AC on in the neighborhood at night when mine's off." Satpal is not aware of the size or brand of the AC, but says it was new in 1997, and is happy with it.

The high end of Satpal's temperature range would be 90 degrees with a fan, or 85 if he's active. He can't say how low the temperature gets at night, but has not closed windows at night because of cold. If guests are arriving, he lowers the temperature to 80 degrees.

At work (Intel in Folsom), he doesn't know what the temperature setting is, but they keep it cooler than at home, and he says it's comfortable.

Asked if the energy problem is serious, he says 'it's serious'. Some politicians and energy providers are responsible. Satpal is not sure what should be done. He thinks new power plants should be built, and solar energy sources should be subsidized. He expects that the current energy projects will go forward: new power plants, better growth forecasting combined with signing advance power contracts.

Asked about the desirability of clotheslines, Satpal says he uses lawn furniture to hang the heavier laundry items (such as sheets, towels, and jeans) on. He says that in India, people call evaporative coolers "air coolers", but he doesn't expect that people here will buy them. He's never experienced photovoltaics, but says he would use them if they were cheaper. No conservation equipment has been added since Satpal moved in, but he is looking into attic fans.

As a result of media campaigns, he's doing laundry after 7pm, even though he has a gas drier. He set the AC temperature higher this year after hearing news reports about the problem.

### ***Rachael Moran***

Rachael, 38, lives with husband Ron, 47, and daughter April, 9, in a four year old two-story, 2280 sf house. Rachael is a program representative for a university extension computers and information systems program.

"We use the AC," says Rachael, "but not that often. I turn it off more than I turn it on, but I do use it. On hot days it's on, if it's above a certain temperature. I honestly couldn't tell you what the thermostat settings." The house has two zones, upstairs and downstairs.

They've added three ceiling fans. "We open and close shades and windows. In the morning, the sun is hitting the back of the house, and the windows and shades get drawn to keep the cool air in. In the evening, we'll open the windows to allow cross-ventilation. If it's really hot at night, we don't open the windows and instead use the AC. Ceiling fans go on when the windows get opened. I'm inevitably turning the fans on at the wrong time; I turn them on when I think the air should be moving. Ron tends to think the air shouldn't be moving when I think it should."

"During the day, I'm not home until 5pm. I'm usually okay with however it (the indoor condition) is. I like fresh air, but if it's 100 outside, I don't open the windows. My first inclination is to take a cold shower. Ron controls the temperature settings because he's home more, and because he's bothered to read the instructions on 'the fricking thermostat'. No conflicts; Ron's cheap, and he's good. Yes, the thermostat is programmable. Somehow Ron programs it to do what's right for the season. It's magic to me. I'll check to see what temperature it is. Watching SMUD and PG+E commercials, they say to keep the thermostat at 76 or 78. Jimmy Carter in a sweater made a big impression on me." Rachael doesn't think there's any difference between her actual and ideal temperature: "I can't remember being stifling hot with the AC on. It's better than my workplace."

(Three out of eight of) "my coworkers don't have AC and use box fans and outside bamboo window shades. But I think we've gone to more lengths to make our house energy efficient. We took energy efficiency into consideration probably more than looks. I think we're zealots, preaching the gospel of weatherstripping."

Rachael doesn't know the size or EEC of the AC, but says the brand is York, and it was installed in 1997 when the house was new. She discounts any need for a new AC, saying, "what's not to like?"

Rachael's high in a range of temperatures is 80, saying "the fans would make 80 comfortable. Without a fan," she says, "80 would be comfortable if I were sedentary. If I were active without the fan, 76." Regarding the cool end of the range, "I pile on blankets

instead of shutting windows, because I want the fresh air. Sixty degrees, maybe, will make me shut the windows, or maybe 65. I've never closed the windows except for noise, when I expect it to be hot the next day." Guests do not make Rachael change the temperature settings.

She works outside the home, saying "I wish work were as comfortable as home. At work, there are more computers and people to make it warmer. In the wintertime you could hang meat in my office; In summer, I think they've set the thermostat at 78, but because of exposure (my desk has a west-facing window) it makes it unbearable at about 3pm. Air doesn't move in the building." When asked if employees are involved in setting the thermostat, Rachael chuckles and says "no". My office mate has complained and they sent someone to measure the temperature.

Of California's current energy crisis Rachael says, "I think it's become a media event, a fabricated crisis brought on by energy tycoon greed. Also, no one paid attention to the growth of the computer infrastructure industry. I'm usually not that much of a conspiracy theorist, but the off-line maintenance of power plants all lined up in February so that California had to buy power on the spot market. I also think this is a way to get everyone to say 'we need power plants', and then 'we need nukes', when what we need is for everyone to conserve energy. What has been done is the 'fast-tracking' of small power plants, which is fine. People are conserving, but God knows how long it'll last. As long as the fear of high priced energy is there, they'll conserve.

Regarding clotheslines, Rachael says "Of course! The stupidest CC&R in existence that we can't have them." She grew up with evaporative coolers, and had one as a young adult. "Yeah, they're noisy, but they work." When asked about photovoltaics, she asks: "I'll bet they can be designed to fit in with landscaping. Aren't they hideously expensive?" They have installed solar shade screen this year, and have talked about a whole house fan.

Regarding the conservation media efforts of utilities and public agencies, Rachael says "We've adjusted how we use the AC: We 'flex out power'," said with the faked German accent of the comic bodybuilder duo on Saturday Night Live in the 70s-80s, "trying to avoid whatever the designated part of the day is. Also, we're cycling energy with, you know, PG&E, those people. I think we've adjusted when our spa is on." [Actually, it's the SMUD AC cycling she refers to.] Regarding the next phase of our project, "Yeah, why not?"

### **Ron Freeman**

Ron, 38, his wife Sue, 39, and son Eric have lived for four years in a two story "Onyx" model, of which only five were built in the subdivision. They use their AC manually, with the temperature set at 82 during the day and 78 at bedtime, at about 11:30 p. m. On hot days, it gets up to 84 or 85 when SMUD is cycling the ACs. This year Ron hasn't noticed the cycling, but last year they cycled it for about four hours and the temperature got up to 92 upstairs.

Ron has added three ceiling fans to the house. He will open the upstairs windows if the outside temperature is cooler than inside, on the shady side first. The thermostat is located near the sliding door, so they adjust by setting the temperatures higher there in the late afternoons. The upstairs thermostat also gets morning sun, so that one is set higher for those hours. Ron uses the fan setting of the central AC system: "If I use the fan

setting with the windows open upstairs, that should, in theory, work.” Sometimes, if the neighbors or street is particularly noisy when they’re trying to sleep, they close the windows.

Eric doesn’t use the AC, and my wife gets cold before I do, says Ron. Both he and Sue control temperature settings. Ron doesn’t know the size of the AC, but was aware of the brand – York – and that the unit was new with the house when they moved in four years ago. He said he’d prefer the smaller model that came with the later homes in the subdivision, since it’s smaller and quieter.

Ron’s range of temperatures is from 83 or 84 with ceiling fans, down to at least 66 or 67, since he’s not seen it cooler inside than that. Further, they’ve rarely closed windows at night because of cold; instead, they usually just add a comforter to the bed.

At work, Ron says his requirements are the same, but it’s maintained as too hot, so he doesn’t achieve comfort. Coming home is nice, because even at 81 or 82, it feels cool. He does have control of settings at work. The last SMUD (electric) bills have ranged from \$45 to \$60.

Regarding the state’s energy problems, Ron thinks we have enough already, and that we’re using too much. However, then he adds “I see all this new construction without the resources (capacity) to support them.” “Government ought to encourage conservation,” and “the current situation is government’s fault,” says Ron. “Look, we’re all driving SUVs. At Altamont pass windmills weren’t operating until this year. BMW has hydrogen powered cars, how about a government rebate to drop the price?”

Clotheslines are not attractive to Ron; a neighbor has one and he hates it, even though he grew up with one in Arizona. Evaporative coolers are okay; “you can put them on the side of the house and they’re no uglier than the outdoors AC units.” Regarding photovoltaics, Ron likes them, but hasn’t looked into prices or other qualities of installing them. They have not added significant conservation equipment since moving in.

### ***Adam Blandon***

Alan, 32, wife Judy, 30, and two children – a toddler and an infant – have lived for three years in a two-story “new Granite” model 2310sf home in Gold River Station. Alan is a Physical Therapist who works days and Judy a Registered Nurse who works long shifts three nights one week and two nights the next week. They have and use a two-zone AC, with both zones usually set to 82. Alan has used the advanced functions to set a three degree offset downstairs and a two degree offset upstairs. They use the system by manually turning it on and off daily, or when they’re at home. “We started using the programming functions,” says Alan, “but my wife would get cold and then change the settings.”

Five ceiling fans have been installed, four upstairs and one downstairs. They do open and close their window coverings, but the windows usually remain closed unless there’s a good breeze. “Last week (when the temperatures were in the 80s we had a good breeze. We’d like to open it up at night but the neighbors next door have a noisy dog that wakes us up starting at about 5am.”

Among the family, Adam ‘runs warmer’, meaning the heat affects him more than it does his wife, so that he tends to cool it down. Judy is already cool and turns the AC off. Adam gets home from work at 5pm and when it’s hot, he adjusts the AC to 80 degrees upstairs. Judy turns it off before it gets down to 80. As we leave the house when

I know company is coming later, I'll turn it down, but if she's the last one out the door, she'll turn it off. Ideally Adam would set the AC to about two degree cooler than their usual 82.

Asked how he felt he compared to others, he says "We don't cool as much as other people we've visited. Listening to what's being promoted, we're average." Adam didn't know the size or brand of the AC. He then explains that he's had 'a big problem' with Beutler. Alan has called them in several times, and a huge block of ice was found on it, and there were cracks in the freon line [actually these have one of the replacement refrigerants], allowing it to vaporize. This is the first summer when they turned it on in spring and it worked.

As a temperature range, Adam estimates the high as 82 or 83 with fans on, or 80 or 81 without. They recently visited family in Ventura, and it seemed cold at 71 degrees, but this was during the day. He couldn't estimate a tolerable low nighttime temperature.

For visitors, Adam will set the temperature down to 80. Rarely will they set temperature below that, except for one specific time they used 77 or 78.

At work, Adam is satisfied with the outdoor climate, although it's a little warmer, as high as 84 degrees. That's okay because there is air movement. Since he works with geriatric patients, the temperature is kept high to help loosen muscles. On occasion, they will turn the AC on for a warm afternoon. If a patient complains, they turn it off.

Adam is equivocal when asked if the energy problem is serious: "If the summer was more extreme, it might have forced more blackouts – earlier in the year we were more conscious of leaving appliances on. The responsibility is with deregulation of supply, mixed with some producers going off line while anticipating that other companies would continue producing. Is it true they haven't built enough power plants for the demand?" he asks. Maybe some resources (power plants) were not available. Asked what should be done, he says, "I'd like to see the old system, pre-deregulation. Probably the State will re-regulate and supply energy."

Adam says, "No on clotheslines." Evaporative coolers are "noisy and produce lots of blowing air." He doesn't know much about photovoltaics. He did add to ceiling fans recently.

The media campaigns have caused the family to raise the temperature setting for the AC a few degrees and run large appliances early in the day. But they've always practiced conservation. "It was a pat on the back, we're on the right track.

### ***Fred and Mary Sandoval***

Fred Sandoval and his family live in an unincorporated Sacramento County community East of Sacramento. The subdivision, which we will call American River Depot, has mostly two story homes built in the last five years. Fred's model, the "Shale", is a five-bedroom, two story house of about 2100 square feet. I talked to Fred on the evening of July 11<sup>th</sup>, in his family room.

Fred, 37 and a software engineer, and Mary, 36 and an aerobics instructor and pre-med student, have a thirteen year old niece that lives with them, and a twelve year old son. When Fred's at home the single-zone thermostat is set at 77 degrees, or 76 degrees if it's particularly warm. When they're not home, they set the thermostat at 80 or 82 degrees.



Their cooling aid of choice is fans -- lots of them: three ceiling fans, two uprights, two circulating fans, and a window fan for nighttime. At first Fred said they hardly open the windows at night, but as we talked, Mary was in and out of the room, and pointed out to Fred that she opens "the entire upstairs" at night. Windows on the sunny side are closed in the morning, others later. They agreed that they don't open the downstairs windows, for security reasons.

Fred said that Mary prefers the house 2 to 4 degrees warmer than he -- high 70s -- whereas he prefers the low 70s. Both of them were in shorts and tank tops or tees (as was I) as we spoke, even though the day had been mild and pleasant (my description), around 85 to 90 degrees with a medium breeze, all day. I note that Fred is rather husky but fit, maybe over 250 pounds, while his wife looks like an aerobics instructor, which is to say muscular in an attenuated wiry way. Fred is "tuned" to 72 degrees, where they set the thermostat in summer until this year, since he truly prefers to wear a tee shirt with another shirt over it, and long pants. He suspects that being raised in Reno causes him to seek a cooler house. When I asked who controls temperature settings, they both said that the other does, which brought a chuckle. Fred agreed that they disagree over the temperature setting, but it was clear they had never discussed it, since both of them expressed some surprise, or chagrin -- "oh, really... huh", when the other described their disagreement. Mary said "that's why I stay upstairs", which surprised Fred, who replied, "oh, I thought you didn't like me". I'm not sure whether this was spoken as fact, or the kind of comedy that couples do for guests. If I had to bet, I'd say it was genuine.

The house has a programmable (Beutler) thermostat, but no one programs it, because they never got the instruction manual. Fred explains that he got a programmable "toy dog robot" for Christmas, and will program that endlessly -- he's been a professional C++ programmer for ten years -- but hates programming the VCR or thermostat, because "they're so cryptic". Fred would use a programmable thermostat if it were easier. (Perhaps, easier may simply involve having the manual.)

"I'm not the most cost-cutting type," says Fred, referring to their admittedly low temperature setting. We use compact fluorescent lights, and do their laundry at night. We are the "freeze the house family", according to my wife. "Other than cooling, we conserve a lot," says Fred. He relates to me a recent Sacramento Bee article extolling the benefit of turning lights, computers, game playstations, and the like off, and convincing teens to do so.

Fred would prefer a dual-zone system -- he said he'd cool the upstairs and have the downstairs set high (over 80). I'm not sure how a two zone system would respond to this, but I may try it myself. Fred's temperature range for the summer is from 77 to the 50s, or maybe 78 to the 50s if fans are on. If the house cools down at night due to open windows, they'll just get out some blankets. They do not change the temperature of the home if guests are arriving.

The workplace requires a cooler temperature, says Fred, because everyone wears long pants and collared shirts. His former office in San Jose was too cold. Working at home last year he kept the house cool, but his office at work in Sacramento has the vent blocked, making it maybe 5 degrees warmer than elsewhere in the building. As a result, Fred uses a fan on his desk at work. The thermostats at places he's worked have been locked up, so that employees have no control. Fred went on to explain that there are

cameras everywhere in the dot com offices, so there is no question of changing the temperature.

California's energy situation is, "from 1 to 10, a ten: serious." Most responsibility should be laid on the power generators, either because there's not enough or they control (manipulate) the market. Next come utilities, because they're not coordinated and lack foresight. Third, the legislature, for not having foresight. "The CAL-ISO doesn't have a clue". Fred thinks there ought to be bigger plants and better management of the system. An interesting energy source he was aware of was done experimentally on a space shuttle mission. A mile-long cable was properly oriented in line to generate from the induced magnetic field of the earth. Apparently, the power so produced overwhelmed the circuits they were designed to supply, it was so successful. Fred feels that the least amount will be done, only that power generators will maximize profits using knowledge of demand and supply and polynomial math. Fred used the phrase "consortium of power generators" to describe a formal body that probably meets in secret to manipulate prices. What should be done? Fred says that an independent consumer-oriented group (agency?) to police the power market.

Clotheslines are not attractive, but Fred would use them if everyone else was. He mentions it being against the CC+Rs. Swamp coolers would be great, says Fred, "I grew up with them, and they're probably healthier". Fred has thought about buying photovoltaics, but has not because of the cost -- "\$20,000, and you're still not done". Their house has ceiling and upright fans, and solar shade screen (Phifer 60%, I note) on the sunny side. Their only energy-conservation investment this year so far is compact fluorescents.

Ads (by CEC and utilities) have had the effect of causing the family to use the washer and dryer at night, and use the power management features to put computers on standby. They cool the house to 77, instead of 72 degrees last year. When they get hot, they turn the fan speed up instead of the thermostat.

Fred is amenable to further research involving monitoring appliances -- as long as any metering devices are surge protected.

### **David Crawford**

David, 39, Connie, 39, and their four children, from 10 to 7, have lived in a two-story 2626sf home in one of the 'villages' of Gold River since 1994. Connie is a physician, and David, who holds a BA in Economics, cares for the family. David believes they 'overuse' their AC. If they're at home, they set the thermostat to 77 degrees. When they leave, the setting goes to 80 or 82, depending on circumstances. Their system has two zones, which they set to the same temperature.

They have three ceiling fans, two floor fans, and three countertop fans, and David wants more ceiling fans in the rooms without them. They're going to install a whole-house fan. For now they put fans in open windows upstairs blowing outward, so that cool air is drawn in open windows downstairs. With two dogs we don't worry about security. When the temperature outside is too warm outside into the evening, David cools the house to 73 or 74 and waits for the outside to get cool at night before opening windows.

David is typically hot, and sweats from any exertion. Connie gets cold. David controls the thermostat, except when Connie gets cold. David will have the windows open, the fan over the bed on, and have no covers while Connie has two comforters.

Occasionally she'll ask me to close window, but mostly it's just grab another comforter. The thermostats are programmable but they do not set the programs. David's ideal temperature is either 72 or 75, depending upon how active he is.

David feels that he uses more energy than friends or neighbors, because he notices that they have set their thermostats higher. He notices his own AC on when others are turned off. "I'm more of an energy waster."

"Four tons", says David when asked the size of the AC, but the brand he is less certain of – "Roule? Or some thing like that." They had to replace the outdoor component, which he identifies as the condenser. He's pleased with the results, given that they had to match the replacement unit with the indoor components, although he had asked if he could upgrade.

David identifies the range of temperatures he would tolerate as from 80, or 85 with fans, down to 60. If they are having a party where there's a lot of guests and maybe cooking, David expects that he'd set the thermostat to 73 or so. David does not work outside the home.

On a scale of 1-10, David views the seriousness of California's energy problem as a seven currently, and perhaps an eight earlier this year. He views the State legislature and Governor as responsible. For a solution, he says jokingly, "shoot all politicians and put scientists in control." He anticipates that "taxpayers will be raped, but the increase in power plants will avert a problem until we outgrow the new capacity."

Clotheslines would be useful – he uses them in the garage currently. David likes evaporative coolers; he has a portable one, purchased for cheap cooling, which he'll leave on until the air in a room becomes saturated. Photovoltaics 'are great', "I'd wish they could put a whole stack on my roof, if they were less costly." David is planning to install a whole house fan, and the house came with a concrete tile roof. They had added compact fluorescents before 2001.

As a result of the media campaigns for conservation, they "keep lights off, and things that don't need to be on."

### ***Stacy and Brian Defelice***

Stacy and Brian, 29 and 28, and 5-year-old Corinne have lived in their two-story Gold River Station home for two years and four months. Stacy manages in a company that provides administrative support in the computer industry, and Brian drives fuel trucks between Tahoe and the Bay Area, delivering to service stations. They use their AC by setting it manually to 78 degrees, both upstairs and down.

Brian has installed five ceiling fans in the house, and is considering how to install a whole house fan. They don't open their windows at night, but will occasionally do so when they're awake.

Neither of them controls temperature settings, they leave it at 78 degrees whether they're home or not. The thermostats are programmable but they do not use those functions. Before this year they set it to 75 degrees. "Brian gets cooler faster," says Tracy, but then goes on to explain that he'll have shorts on while she wears long sleeves, which suggests that she actually gets cool faster, but that Brian exposes more skin in an effort to.

Brian says they are average when compared to the neighbors, and Tracy agrees. Neither is aware of the size of the AC. Brian says the brand is York, and Stacy disagrees, “No it’s not.” Both agree it works fine, but Stacy says she doesn’t deal with the AC.

Stacy describes her zone of temperature tolerance as from 82 degrees down to 70, and Brian says his is from 79 degrees down to 70. They don’t change the settings for guests.

Stacy’s workplace, arranged as one large room with cubicles, is kept cooler. “They continually keep it cold even though they announced a program to conserve.” Brian is continually in and out of his air conditioned truck, so he keeps is cool but warmer than at home. Stacy says he does this so the contrast of temperatures doesn’t give him nosebleeds. Brian says, “Oh great, now I’m going to be the guy with the nosebleeds.” I ask if this is true, and he agreeably admits so.

Brian says “it’s all political”, and illustrates by saying that the PG&E people say they’re shut down for maintenance, without checking who else might be down. “We generate more than we need,” says Brian, and “Ever since Wilson when they devised it (deregulation), it wasn’t true deregulation.” Brian points out that the ISO sets prices based on the highest bid and says, “Who buys at the highest bid?”

Stacy says “If it’s bad as they say it is, why are we allowing new building? I don’t think it’s as serious as they said. My ideas have evolved over the summer.” Asked what should be done, Tracy says I’d have to think...” Brian answers “A true deregulation, and find a way to get us out of those long-term contracts that we bought into at the high end of the scale.”

Asked what will be done, Tracy thinks, “They’ll re-activate some old plants, build new ones, and build some alternatives like wind.” Brian: “I don’t think we’ll do anything – business as usual – a lotta talk.”

Both agree that they wouldn’t use clotheslines. Tracy says her uncle in Auburn had one, and she liked it. Brian says he likes swamp coolers, that he grew up with them. Tracy says she’d consider doing photovoltaics, and Brian agrees, saying “No problem. I don’t know what the initial costs would be, though. My granddad had some.” They have added the ceiling fans, and are planning for a whole house fan or an attic fan. They wanted to add solar shade screen, but the quote they got was too high.

They’ve changed very little as a result of the media campaigns, except for setting the thermostat from 75 degrees up to 78.